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ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement page 8.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

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OF ALL DESCRIPTIONS.
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See half-page Advert. last week and next week. 2087

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See Advertisement last week, page 19.

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See Page 75.
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Specification and Workmanship equal to Main Line Locomotives.
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Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 617
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See Advertisement, page 88, May 9.

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Worm Wheels cut up to 13 ft. diam.
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MANNING, WARDLE AND COMPANY, LIMITED.
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See their Illus. Advertisement, page 95, last week.

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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1738 & 1737. Wire: "Rapidising, London."—Great Eastern Road, Stratford, E.15. 1794

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MECHANICAL ENGINEERS,
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AND
Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW BIRMINGHAM LONDON.
See Advertisement, page 56. 1872

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PETERBOROUGH.
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GAS AND OIL ENGINES.
AIR COMPRESSORS.
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See Advertisement, page 55, May 9.

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London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX
Makers of
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Refrigerating and Ice-making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers,
&c., &c. 1586

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Telegrams: "Eps," London.
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CALORIFIERS EVAPORATORS,
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SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

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LAND AND MARINE
YARROW BOILERS. 1583

Matthew Paul & Co., Ltd.,
LEVENFORD WORKS, Dumbarton. 1489
See Full Page Advt., page 40, April 25.

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Walter Somers, Limited,
HALESOWEN. 7116

Taylor & Challen
Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 98, April 25 8195

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 62. 2402

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 2006

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Hurst, Nelson & Co., Ltd.,
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3382

HEAT INSULATION.
CELITE PRODUCTS CORPORATION,
Windsor House, Westminster, S.W.1. 1675
See our Illustrated Advertisement, May 9.

GEARS OF EVERY DESCRIPTION.
Spring Grove,
AUTOGEARS (LEEDS), LTD., Hyde Park Road, Leeds. 2153

Patents.—Exhibition Visitors
can obtain information respecting patents, etc., from B. T. KING, Regd. Patent Agent, 146A, Queen Victoria St., E.C.4. For free appointment Wembley Exhibition, 'Phone Central 682. Handbook free.

Locomotive Traversers
(ELECTRIC). 1357
S. H. HEYWOOD & CO., LTD., REDDISH.

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1948

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
1676
See half-page Advertisement, page 73, May 9.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.
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Degree, Associateship, and Works Pupils' Courses.
Applications are also invited from those desiring to do Research Work in Engineering.
Full particulars may be obtained from PROFESSOR LEA, Department of Applied Science, St. George's Square, Sheffield.
W. M. GIBBONS, Registrar. D 621

Norton & Gregory Engineering SCHOLARSHIPS, 1924.

The following Scholarships, total value £450, have now been awarded:—
DOUGLAS JAMES THOMAS HAYNES.—Charterhouse School, Godalming; £80 per annum, tenable for three years at Cambridge University.
JOHN PHILLIP BERKIN.—Taunton School; £50 per annum, tenable for three years at Cambridge University.
THOMAS BLENCH.—Allan Glen's School, Glasgow; £20 per annum, tenable for three years at Glasgow University. D751

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58 SOUTH JOHN STREET, LIVERPOOL. 1993

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2108

TENDERS.

BENGAL-NAGPUR RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for:—

(A) STEEL TYRES.
(B) AXLEBOX FACEPLATES.

Specifications and Forms of Tender can be obtained at the Company's Offices, 132, Fresham House, Old Broad Street, E.C. 2, on or after 12th May, 1924.
A fee of 20/- will be charged for Specification (A), and 10/- for (B), which are NOT returnable.
Tenders must be submitted not later than NOON, on Tuesday, 27th May, 1924.
The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the orders.
By Order of the Board,
R. C. VOLKERS, Secretary.
D 740

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Wednesday, 28th May,

Tenders for the Supply of

(1) METALS.
(2) MATERIALS for Steel Foundry.
(3) WOOD SCREWS, NAILS, SPLIT-PINS, etc.

Tenders must be made on forms, copies of which, with Specification, can be obtained at these Offices on payment of 20/- each for No. 1 and 10/- each for Nos. 2 and 3 (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.
S. G. S. YOUNG, Secretary.
Offices: 91, Petty France, Westminster, S.W.1.
12th May, 1924. D 753

SALFORD UNION.

UNION INFIRMARY, PENDLETON, NEAR MANCHESTER.

RE-ADVERTISED DUE TO DEATH OF CONTRACTOR'S PRINCIPAL.

The Salford Board of Guardians invite

Tenders for Heating and Hot WATER SERVICE APPARATUS,

including Calorifiers, Pumps, Mains, Radiators, and the like, for above Infirmary and Nurses' Homes Extension.
Drawings of the Plant may be inspected at the Offices of the Engineer, Mr. T. ROLAND WOLLASTON, M.I.M.E., Lord's Chambers, 26, Corporation Street, Manchester, on or after May 19th, between the hours of Ten a.m. and Four p.m.
Specification, Schedule of Quantities, Form of Tender and Conditions of Contract may be obtained from the undersigned, on receipt of written application, enclosing cheque value Two Guineas, which sum will be refunded on due receipt of *bona-fide* Tender.
The Board do not bind themselves to accept the lowest or any Tender.
The selected Contractor will be required to subscribe to the Conditions as regards employment of labour, etc., as set forth in the Board's regulations.
Sealed Tenders, endorsed "Engineering Section 2," must be delivered at my Offices, not later than Ten a.m. on Saturday, June 14th, 1924.
By Order,
R. H. INCHLEY, Clerk to the Guardians.
Poor Law Offices,
Hodes New Road,
Salford.
13th May, 1924. D 757

SOUTHWARK UNION.

TO HOTWATER ENGINEERS, BUILDERS AND OTHERS.

The Guardians of the above-named Union invite

Tenders from Contractors to

CARRY OUT the Undermentioned WORK at the Southwark Hospital, East Dulwich Grove, S.E., in accordance with the General Conditions of Contract, Specification, and Drawings prepared by their Engineer.
(A) Providing and installing two Calorifiers, Steam Mains, Hot Water Mains, and Connections thereto.
(B) Forming New Heater Chamber and alterations to existing Heater Chamber.
Persons desiring to Tender may obtain General Conditions of Contract, Specifications and Drawings, together with Form of Tender, from the Clerk to the Guardians, as under, upon payment of a deposit of £2, which will be returned on receipt of a *bona fide* Tender. Applications for Tenders to be made between the hours of Ten a.m. and Four p.m. (Saturdays, Ten a.m. to Twelve Noon).
Tenders to be signed, sealed and delivered (in the envelope provided) to me at the Guardians' Offices, Ufford Street, Blackfriars Road, S.E.1, not later than Ten a.m. on Thursday, the 29th May, 1924.
The Guardians do not bind themselves to accept the lowest or any Tender.
By Order,
A. P. STANWELL SMITH, Clerk to the Guardians.
Union Offices,
50/51, Ufford Street,
Blackfriars Road, S.E.1.
10th May, 1924. D 742

SITTINGBOURNE URBAN DISTRICT COUNCIL.

PROPOSED RE-ARRANGEMENT OF SEWERAGE WORKS PLANT.

THE SITTINGBOURNE URBAN DISTRICT COUNCIL are prepared to receive

Tenders for the Supply and

ERECTION of PLANT for their Sewage Disposal Works, Sittingbourne, as follows:—
TWO HORIZONTAL OR VERTICAL FOUR CYCLE CRUDE OIL ENGINES. Each 50 B.H.P., TO START WITHOUT USE OF EXTERNAL HEAT, TOGETHER WITH AIR COMPESSORS; ALSO AUXILIARY AND TEMPORARY PLANT, Etc.
Preliminary Plans may be inspected, and specification and forms of Tender obtained on and after 12th May, 1924, on application at the Offices of the Council's Engineer, Mr. T. W. ELLIS, 110, Victoria Street, Westminster, London, S.W., or at the Office of the Surveyor to the Council, Mr. M. W. LASHMAR, Town Hall, Sittingbourne.
For each specification a deposit of £3 3 will be required, which sum will be returned to the Tenderer, provided that he shall have sent in a *bona fide* Tender, based on the specification, etc., and which has not been withdrawn prior to the definite acceptance of a Tender by the Council.
Duplicate copies of the Specification will be supplied at a charge of 10/6 each (not returnable).
The copy of the Specification supplied is to be returned intact with Tender Form, filled up and signed, addressed to the undersigned, and to be received by him before Noon on the 2nd June, 1924, enclosed in a sealed packet marked on the outside "Tender for Sewage Disposal Plant."
The lowest or any Tender will not necessarily be accepted, nor will any expense in connection with Tendering be defrayed.
G. H. POTTER, Clerk to the Council.
76, High Street, Sittingbourne. D 709

METROPOLITAN WATER BOARD.

MAIN, KEMPTON TO CRICKLEWOOD. TENDERS FOR SECTION No. 2.—LAYING 48 in. CAST IRON MAIN, and Contingent Works from Greenford to Cricklewood and the LAYING of 27 in. CAST IRON PIPES from near Hanger Lane to Ealing.

The Metropolitan Water Board Invite

Tenders for the Laying and

JOINTING of about 8445 yards of 48 in. diameter CAST IRON WATER MAIN, principally through fields, and also the laying of about 1620 yards of 52 in. STEEL PIPES, mainly in subways: from Windmill Lane north of the Board's existing Valve House in the Parish of Greenford, to the Board's Works at Cricklewood, in the Parish of Willesden, together with about 1447 yards of 27 in. diameter CAST IRON MAIN branching from the 48 in. diameter main near Hanger Lane in the Parish of Wembley and extending to the neighbourhood of the Board's Fox Reservoir in the Parish of Ealing, all in the County of Middlesex.
Drawings, Conditions of Contract and Specifications may be inspected without payment of a fee at the Offices of the Board, Chief Engineer's Department (Room 201) on and after 14th May, 1924.
Form of Tender, Conditions of Contract, Specification, Bills of Quantities and Schedules of Prices, together with drawings and a spare copy of the Bills of Quantities and Schedules of Prices, may be obtained on and after 19th May, 1924, from Mr. HENRY B. STILGOE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £30, which sum must be deposited with the Accountant to the Board, and will be returned on receipt of a *bona fide* tender, accompanied by all the above-named documents and drawings (with the exception of the spare copy of Bills of Quantities and Schedules of Prices, which may be retained by the Tenderer). Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m. (Saturdays Ten a.m. and 12 Noon). Cheques must be made payable to the "Metropolitan Water Board" and not to individuals.
Tenders enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, New River Head, Clerkenwell, E.C.1," and endorsed "Tender for Main, Kempton to Cricklewood, Section No. 2," must be delivered at the Offices of the Board (Room 123) not later than Ten a.m. on Thursday, 5th June, 1924.
The Board do not bind themselves to accept the lowest or any Tender.
G. F. STRINGER, Clerk of the Board.
Offices of the Board,
New River Head,
Clerkenwell, E.C.1.
6th May, 1924. D 714

The Director-General,

INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES:—
WHEELS AND AXLES.
Tenders due on the 27th May, 1924.
Tender forms obtainable from above. D 769

GREAT SOUTHERN & WESTERN RAILWAY (IRELAND).

CONTRACTS, 1924.
The Directors of the Great Southern and Western Railway Company are prepared to receive

Tenders for the Supply of the

undermentioned STORES for Six Months commencing 1st July, 1924.

	No. of Form.
Acid, Sulphuric ...	3D
Asbestos Sheeting, etc.	40
Baskets	10
Bolts, Nuts and Rivets	15
Brooms and Brushes	13
Brass Fittings for Carriages... ...	18
Do. do. for Water	26A
Do. do. for Gas ...	26B
Canvas and Sacks ...	6
Canvas for Wagon Tarpaulins	6A
Castings, Mall. Iron	11
Carriage Laces ...	7A
Cloth for Carriages	7C
Clothing, I.R. proofed	9B
Coach Screws and Washers	15
Colours	2
Corks	39
Cotton Waste ...	5A
Crucibles	41
Drysalteries	3
Emery and Glass Cloth, etc.	26
Files and Tool Steel	20
Fire Bricks and Clay	33
Foundry Requisites	42
Galvanized Sheets, Buckets, etc. ...	23
Grates, Stoves ...	24
Grindstones	38
Glass, Sheet, and Plate	27A
Glass and China Sundries	27B
Hardware (Sundry)	17
India Rubber Goods	9A
Implements, Sundry	21
Iron Tubes and Fittings	29
Leather and Leather Goods	12
Locks and Keys ...	19
Mantles for Gas ...	26C
Mats, Fibre	10
Nails	31
Nuts, Hex. Black and Bright... ...	15A
Packings	40
Plumbago	41
Railway Fastenings	16
Rain Water Pipes and Gutters	25
Ropes, Twine & Flax	4
Soaps	30
Sewer Pipes, Plaster of Paris, etc. ...	32
Shovels, Spades, etc.	21A
Sponge Cloths ...	5
Signal Wire Pulleys	11
Screws and Split Pins	14
Tin Plates	22
Waste	5A
Waterproof Clothing	9B
Wicks	5
Wire, Fence and Signal	30A
Wirework	30B

Forms of Tender can be obtained on PAYMENT of 6d. each from the STORES SUPERINTENDENT, GENERAL STORES DEPARTMENT, G.S. & W.R., INCHICORE, DUBLIN. Applications for forms by Post must be accompanied by Postal Order. Stamps cannot be accepted. All enquiries for information should be also directed to the Stores Superintendent.
Patterns may be inspected at the General Stores Department on and after the 19th inst., between the hours of Ten a.m. and Four p.m. (except on Saturdays).
Tenders must be enclosed in the special envelope supplied for the purpose with each schedule, and must be posted so as to be with the undersigned before Ten a.m. on Wednesday, 4th June, 1924.
The Directors will not consider any Tender unless it is furnished on the Company's Form, and do not bind themselves to accept the lowest or any Tender.
By Order,
C. R. RILEY, Secretary.
Kingsbridge Terminus, Dublin, May, 1924. D 764

MIDLAND GREAT WESTERN RAILWAY OF IRELAND.

CONTRACTS FOR 1924.

The Directors of the Midland Great Western Railway of Ireland Company are prepared to receive

Tenders for the Supply of the

undermentioned STORES. The Contracts to commence from the 1st of July next, for six months.

	No. of Form.
Asbestos & Packing	1
Barrows and Trucks	2
Baskets and Mats	3
Brushes, Brooms, &c.	4
Brass Fittings for Gas and Water	5
Bolts, Nuts and Rivets	6
Bricks, Slates, Earthenware Pipe, &c.	7
Chain	8
Cement	9
Candles and Soap	10
Carriage Fittings	11
" Trimmings	12
Clothing	12A
Creosote Oil	13
Drysalteries	14
Fog Signals	15
Farm Produce Boxes	15A
Glass	16
Grease	17
Gas Mantles, &c.	18
Iron and Steel Forgings	19
Iron Castings	20
India Rubber Goods	21
Lime	22
Leather and Belting	23
Lamps and Tinware	24
Locks, Rainwater Goods & Hardware	25
Oils	26
Paints, Colours and Wallpaper	27
Ropes and Canvas	28
Screws, Split Pins, Nails, &c.	31
Sheet Tin, Lead, Gun Barrel, &c.	32
Steel Tyres, Axles and Plates	33
Steel & Copper Tubes, Copper Plates and Ingots	34
Steel Castings	35
Staffordshire Iron, Wire, &c.	36
Springs, Steel, and Files	37
Soft Goods	38
Timber, &c.	39
Tools	40
Tool & Barrow Shafts	41
Varnishes	42
Wagon Covers and Tarpaulins	43
Waste and Wicking	44
Yorkshire Iron	45

Forms of Tender can be obtained, on payment of 6d. each, from the STOREKEEPER, GENERAL STORES DEPARTMENT, BROADSTONE STATION, DUBLIN. *Please do not send Stamps.*
Patterns and Samples can be inspected at the same place on and after 19th instant, between the hours of Ten a.m. and Four p.m. (Saturday, Ten a.m. to Twelve noon).
Contractors cannot be allowed to tender to supply goods to their own patterns, nor can the Company's patterns be sent away for inspection.
The Directors will not consider any Tender unless furnished on the Company's forms; nor any Tender in which any alteration of the form has been made.
The Tenders to be sent in by post, sealed and endorsed on the envelope, "Tender for Stores, Form No. ....," and addressed to "The Chairman, Broadstone Station, Dublin," so as to reach him on or before Ten a.m. on the 2nd June.
The Directors do not bind themselves to accept the lowest of any Tender.
By Order,
PHROY A. HAY, Secretary.
Broadstone Station, Dublin, May, 1924. D 728

PORT OF BRISTOL.

NEW ELECTRIC CRANES, BRISTOL CITY DOCKS.

The Docks Committee are prepared to receive

Tenders for the Construction

of THREE 2-ton MOVABLE ELECTRIC JIB CRANES, and the ERECTION of the same on the roof of Shed "U" (now in course of reconstruction), Canon's Marsh, Bristol City Docks.
On and after Tuesday, the 13th day of May, 1924, copies of the General Conditions, Specification, Schedule of Prices and Contract Drawing can be obtained from the undersigned on production of a receipt showing that a deposit of £5 has been paid to the Bristol Docks Committee (TO WHOM ALL CHEQUES MUST BE MADE PAYABLE), 19, Queen Square, Bristol. The deposit of £5 will be returned hereafter to all *bona fide* Tenderers.
Tenders must be enclosed in a sealed envelope, endorsed "Tender for Three Electric Cranes," and addressed to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him, accompanied by all the prescribed documents and drawings, before Ten a.m. on Monday, the 9th day of June, 1924.
The Docks Committee do not bind themselves to accept the lowest or any Tender.
THOMAS A. PEACE, Engineer, Port of Bristol.
Chief Engineer's Office, Avonmouth Docks.
9th May, 1924. D 699

CITY OF LIVERPOOL.

TRAMWAY MATERIAL.

The Corporation are prepared to receive

Tenders for the Supply and

DELIVERY of various classes of TRAMWAY MATERIAL, as under:—
SCHEDULE No. 1. Steel Tramway Rails and Fishplates.
SCHEDULE No. 2. Steel Fishbolts.
SCHEDULE No. 3. Steel Trebars.
SCHEDULE No. 4. Copper Bonds.
Firms are required to state clearly, when making application for the necessary Tender Forms, the name and number of the Schedule for which they desire to be furnished with Tender Form.
Duplicate Forms of Tender for record purposes will NOT be supplied.
Tender Forms will be forwarded UPON RECEIPT OF APPLICATION IN WRITING to:—
THE CITY ENGINEER, Municipal Buildings, Dale Street, Liverpool.
Tenders must be sealed and enclosed in the official envelopes provided, endorsed in accordance with the instructions given on the Form of Tender, and FORWARDED THROUGH THE POST, addressed to:—
"The Town Clerk, Municipal Buildings, Liverpool."
LATEST TIME AND DATE FOR RECEIPT OF TENDERS:—
TEN O'CLOCK A.M., ON FRIDAY, THE 23rd MAY, 1924.
WALTER MOON, Town Clerk.
1st May, 1924. D 690

APPOINTMENTS OPEN.

THE UNIVERSITY OF MANCHESTER.

Applications are Invited for

the POST of ASSISTANT LECTURER in ENGINEERING. Stipend £300 per annum.
Candidates should have some Civil Engineering experience and be able to give assistance in the Surveying Field courses.
Applications should be sent to the Internal Registrar not later than 21st June.—Further particulars may be obtained on application to the INTERNAL REGISTRAR. D 595

STAFFORDSHIRE EDUCATION COMMITTEE. COUNTY TECHNICAL COLLEGE, WEDNESBURY.

An Assistant Lecturer is

REQUIRED to begin work in September. Salary will be paid according to the Burnham (Technical) Scale, less the 5 per cent. abatement for the current financial year. Candidates must be qualified to give class-room and laboratory instruction in Physics and Mathematics. Works and Drawing Office experience in Electrical Engineering is desirable. Further particulars and forms of application, which must be returned not later than May 31st, 1924, may be obtained from the undersigned on receipt of a stamped addressed envelope.
GRAHAM BALFOUR, Director of Education.
County Education Offices, Stafford, 3rd May, 1924. D 685

Metallurgist Wanted for

London position. Knowledge of non-ferrous metals, particularly light alloys. Metallurgical works experience desirable, also knowledge of materials for petrol engines. Salary £350 to £450 according to experience and qualifications.—Address, D 776, Offices of ENGINEERING.

Ratefixer Required (London

Dist.). Must have good recent experience in laying out operations and fixing prices for manufacture of motor parts in large modern factory.—Address, with full particulars and copies of testimonials, D 761, Offices of ENGINEERING.

The Royal Air Force

REQUIRES ELECTRICIANS, ELECTRICAL FITTERS, POWER STATION TRADESMEN and WIRELESS OPERATORS. Age limits 19 to 30. Pay from 24/6d. to 38/6d per week, on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call, INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, London, W.C.2. D 385

Applications are Invited for

the POST of WORKS ENGINEER by SOUTHALL BROS. & BARCLAY LTD., for their Surgical Dressings branch at Charford Mills, Saltley, Birmingham. Experience in handling labour and good organising qualities necessary. Wages £5-10-0 weekly for first year also house, coal and gas. Applicants should be 30-35 years of age.—Please apply by letter, in confidence, and with full particulars of present position, to MANAGING DIRECTOR. D 722

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THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of the above Institution was held at 6 p.m. on Friday last, the 9th inst., the chair being occupied by Mr. W. H. Patchell, the President.

IRRIGATION PUMPING MACHINERY.

A paper entitled "Irrigation Pumping Machinery (Gezira Scheme), Sudan," was read by Mr. Richard W. Allen, C.B.E., Vice-President, who also exhibited a large number of lantern slides illustrating the machinery and the progress of the work. We commence to reproduce this paper in abridged form on page 654 of this issue.

Mr. Roger T. Smith, who spoke first in the discussion, remarked upon the courage of an enterprise involving the use of 1,000-h.p. Diesel engines in the wilderness. A considerable acreage of cotton was dependent upon the pumps installed, and it was satisfactory to note that the plant had worked continuously and successfully since July last. He had had the pleasure of seeing them working just before Christmas, 1923. With the three engines at work the pumps delivered 2,000 tons of water per hour. That was only a small fraction of the total amount of water to be delivered to the 300,000 acres which would be under irrigation when the Makwar Dam was completed. It had now been definitely determined that the soil of the Gezira was suitable for the growing of cotton, and the scheme was therefore of immense value to the cotton supply of the Empire. The labour, as had been mentioned, was not derived from the Sudanese, but mainly from the West African Mahommedans working their way across the country to Mecca, stopping at various places on the way to earn some money. He thought it quite possible that, with such conditions as those existing in the Sudan, many of the pilgrims would never get to Mecca at all.

He wished the paper had given more information about the construction of the pumps, and regretted that, in a scheme of such magnitude, no provision had been made for measuring the delivery water; this would have been interesting in view of the complete and exhaustive trials made of the engines. He would like to mention that, in all his visit to the Sudan, he had not so much as seen a British motor-car in that country, or in Egypt. The Sudan was one of the few places left in which British enterprise was more or less supreme, and he felt that British engineers should pay more attention to business prospects out there. There was a need for charcoal-gas producers (charcoal was readily obtainable in the region of the Nile Valley) for internal-combustion engines. Coupled with that, seeing that the Diesel or semi-Diesel engine was used in almost every part of the Sudan, some cheap and reliable method was wanted of turning the constant torque engine into a variable-speed, variable-torque engine, on some such principle as had been worked out by Dr. Hele-Shaw, but less expensive. This remark applied to the locomotive on the rail, to the engine on the steamer on the river or canal, as well as to the road vehicle.

Mr. C. D. Hodgson, of the Sudan Government Railways, spoke next. He believed that the Government had made every effort to increase enterprise in the Sudan, particularly in the development of agriculture, and had been exceptional among Governments in that way. Great things were expected of the Wad-el-Nau scheme, although it was possibly only of a temporary nature. The utility of the pumping station, as a forerunner of the large canalisation scheme, lay in the fact that it inaugurated the more extensive method of cultivation which was to follow.

Mr. F. H. Livens, commented on the difference between the Sudan as it is at present and as it was before being re-conquered by Lord Kitchener. The population was said to be 8½ millions before the Dervishes and the Mahdi depopulated it, reducing the number to 2½ millions. The figure was now, however, 2¾ millions. He could not help expressing the feeling that if the government of the Sudan were handed over to Egypt the progress of the region would never achieve the promise it now gave under the British régime. He had been struck by the great amount of work in the Wad-el-Nau scheme accomplished in a period of 12 months. The climate of the Sudan was not over good, and for two months of the year rain put a stop to most work; this made the feat more striking.

Mr. H. J. Deane said he was struck, in the case of the Wad-el-Nau installation, by the very nice run obtained for the suction pipes. Dock engineers generally paid insufficient attention to the design of the suction side. Normally, in that work one would find an open channel in which was a slight gradient from the water of the river (or other source) to the intake of the pipes, with the suction pipes dipping down vertically. All the gain obtained by the hydraulic gradient from the river to the suction orifice of the pumps was thrown away in this sudden change of direction. In the Wad-el-Nau installation the run was from the intakes right into the pump without any material change of direction. He would be much interested to know the overall efficiencies of the plant, as these were of great importance in connection with such a pumping scheme. It was unfortunate that no arrangements had been made for metering the water. He suggested that, even now, it would not be a difficult matter to introduce Pitot tubes, or differential diaphragms with suitable meters, at no great cost. No mention had been made in the paper of the cost of the installation. He was aware that the heavy transport charges made it difficult to give costs. Still, it would be useful to members to know the actual cost. Much had been heard about variation in temperature and the need of having expansion joints in the pipes during construction. The author had not stated the range in temperature. He understood the radiation at night in countries such as the Sudan was so intense that in the middle of summer ice might be formed on open water. He would, moreover, like to know what class of fuel was used for the engines. Probably it would be a residual oil, with all the more volatile spirit removed on account of the high temperature of the locality.

Mr. L. St. L. Pendred said he was not clear as to whether the station which formed the subject of the paper was or was not to be jettisoned as soon as the Sennar Dam was opened, or whether some further use would be found for it. It was a big and expensive station, and it was to be deplored if it were used only for 18 months or two years. He would also like to know who inaugurated the scheme.

Mr. E. R. Dolby said the last of four pumping stations—that under discussion—was provided with oil engines and centrifugal pumps. He felt entitled to suppose that the experience obtained with the working of the other three stations had led the authorities to consider that to be the best system. Were the other three stations of different types? Long reaches of the Nile were congested with vegetation known as sudd, consisting of reeds about ¾ in. in diameter, and this had to be cut at frequent intervals to permit of navigation. Some years ago he understood that it was satisfactorily proved that the sudd could be used to produce a good quality of gas. If this could be done in Egypt on a commercial basis, and the gas produced used in gas engines, or in such a system as the Humphrey pump, the results would be of great interest.

Professor P. M. Baker said with regard to expansion joints, he had seen numbers of expansion joints in India under conditions of temperature ranging from 150 deg. in the sun to freezing point at night, and, generally speaking, during erection the expansion was very considerable; afterwards, however, there was practically no expansion, the water keeping the temperature about constant.

Mr. R. W. Allen, in reply, with regard to the absence of data relative to the measurement of the water, said that in such a scheme it was necessary to limit initial cost in many directions, to meet the requirements of the Government. The first scheme included a Venturi meter in the discharge pipe for each pump, but this detail was subsequently eliminated. Mr. Smith would, however, be glad to know that Venturi meters had since been ordered, had been completed, and were now being installed. The efficiency of the pumps had been calculated at 82 per cent. He shared Mr. Roger Smith's regret that only one type of motor-car—the Ford—was in use in the Sudan, especially as there were plenty of good English makers whose cars could work equally well with the conditions there. Although he had travelled in many countries, he had found no community of people happier or more loyal to each other than in the great centres of Sudan. Fortunately, the Sudan Government was almost entirely British; there was no foreign element present.

In the three other stations, two had steam installations and one Diesel oil engines. The steam engines were of German make; the Diesel engine was Swiss manufacture. He, among others, had urged upon the Sudan Government that British makers were as capable as the Germans or Swiss, and in the result a British firm had been given an opportunity in connection with the scheme outlined by the paper, and had come out of it successfully. Nothing seemed too much trouble for the Sudan Government, and they would do anything to help British people, provided they had a genuine business in the country. Information with regard to costs had been purposely omitted from the paper because, being Government work, he had been requested to keep entirely to the engineering side and not to disclose details of expense or anything likely to provoke contention. As to the difference of temperature, at noon the atmospheric temperature was 97 deg.; at night it fell about 25 deg. That was an advantage in the Sudan. In many places the night temperature was about the same as that of the day, and no rest could be obtained. There was some difficulty in giving an analysis of the fuel oil, because the oil was in the hands of the Egyptian Government and was, he believed, varied almost from day to day. At Suez, the Government had lately put down an up-to-date extraction plant, and were practically extracting everything, with the result that it was hard to know what, in the way of oil, would be procurable next. Sir William Garstin originated the Gezira scheme and Sir Murdoch Macdonald had developed it, and the engineers had subsequently improved it; it was not the work of any one man. The great dam was started by the Sudan Government before the war, with the aid of an Italian contractor, who did much good work before it had to be suspended. The building of the station was necessitated by the fact that the Government had promised water for the cotton crop by the end of 1923, and they had to keep their word. Whether the pumping station would remain or not was difficult to say; probably it would. He hoped his paper would help people at home to realise what was being done abroad, and would bring home to young engineers who found little to do here, the potentialities of countries like the Sudan. The true Britisher would be sure of a welcome.

The President then proposed a vote of thanks to the author, following which he announced that an extra general meeting would be held this evening at 6 p.m., to discuss the Third Report of the Steam Nozzles Committee.

SCIENCE AT THE BRITISH EMPIRE EXHIBITION.—II.

IN the natural order of inspection a visitor seeking scientific exhibits would begin with the collection that the Royal Society has organised in the Government Pavilion. One consequence, however, of the unforeseen difficulties sprung upon the Exhibition Executive in the period immediately before the opening has been to delay the supply of electric energy to some of the exhibits, and, unfortunately, the exhibits that have so suffered include that of the Royal Society. It is expected that this final handicap to the great labour involved in completing the exhibit will have been overcome before long. Meanwhile it will be convenient to begin the more particular description of individual exhibits with those of the National Physical Laboratory, which are to be found in the Palaces of Engineering and Industry. In addition to those already mentioned, a small but notable exhibit is included with that of the Non-Ferrous Metal Trades Committee at Stand 237, S.W. Block, Bay 3–5. There is, indeed, a distinct advantage in beginning with the National Physical Laboratory's work, because of its intimate

connection with applied as well as pure research. The present article deals with what is contributed by its Metallurgy Department, which consists almost entirely of applied research.

Not the least interesting part of these exhibits illustrates the equipment and methods of the Department, themselves largely the result of work and experience in the Laboratory itself. The general arrangement of the foundry is illustrated in Fig. 1. It is a large and convenient building with a 3-ton travelling crane; the pits, which are gas fired, are occupied respectively by a furnace for preheating moulds up to 500 deg. C., a Fletcher-Russell injector furnace reaching 1,400 deg. C. and taking 100 lb. copper, and a Richmond natural draft furnace reaching 1,000 deg. C. and taking 150 lb. On the right is a gas muffle giving temperatures up to 1,000 deg. C., at the back a Morgan electric tilting furnace and a salt bath for heat treatment, and behind the Morgan furnace a practically soundproof chamber with injector furnaces for high temperature work, the noise of which is considerable. A gas muffle furnace, 4 ft. 6 in. by 1 ft. by 5 in., with auxiliary air blast reaches 1,350 deg., and three ribbon-wound electrical resistance muffle furnaces, from 12 in. diameter by 6 ft. long to 3 in. diameter by 2 ft. 3 in. long, give from 550 deg. to 900 deg. respectively.

These items do not go outside the run of ordinary good practice, but the range of kilns and furnaces seen along the left-hand side show a good deal that is unusual. Thus Fig. 2 shows a kiln, used mostly for firing refractories and melting glass, accommodating muffles 2 ft. 6 in. by 2 ft. by 2 ft. high, which is brought to 1,500 deg. C. by the combustion of 600 cubic ft. of gas per hour under natural draught with recuperators, and with a somewhat higher consumption of gas gives 1,700 deg. It is built of Glenboig bricks, with a wash of carborundum. Another furnace, used in particular for preparing small quantities of very pure metals with high melting points (chromium and iron), is of the Northrup type, consisting of a high frequency (20,000 ~) furnace and converter, with a step-up transformer (200–6,000 volts), condensers, and spark gap. A still less usual furnace, worked out in the Laboratory, and shown in Fig. 3, with a section in Fig. 4 and illustrating one form of its heating arrangements; it is heated by electric carbon-ring resistances. These consist in all forms of a series of superposed carbon rings, the resistance arising from the imperfect contact of successive rings, as in a well-known rheostat. These are kept in contact by a heavy graphite cylinder with water-cooling tubes, which fits on and is supported by the slightly coned circumference of the upper part of a graphite sleeve resting on the topmost resistance. The lower part of the furnace is coned inwards, and is filled by an inverted cone in graphite, on which stands either the object to be heated or a muffle containing it. The current is introduced through water-cooled graphite electrodes at the base, making contact with a heavy graphite ring, on which rests the column of resistance rings. The furnace is usually closed at top by an arrangement (not shown on Fig. 4) enabling an atmosphere of nitrogen to be maintained in and around the furnace and muffle, the whole being enclosed in a steel case, from which it is heat-insulated with soot. The available heating space above the inverted cone is about 21 in. by 7 in. diameter. The furnace works up to 2,500 deg. C., or, with slight modifications—which, in fact, simplify the construction—up to 3,000 deg. The apparatus in Fig. 3 between the gas cylinder and the furnace is a purifying train for the nitrogen; the oxygen is absorbed in this by copper turnings maintained at 650 deg. by the induction furnace shown on the shelf. A half-size model of the carbon-ring furnace is shown in the Chemical Trades Section.

For the control of the temperatures of these furnaces two notable contrivances are shown in operation, a number of radiators being substituted for the furnace to absorb the energy of the main circuit. One is a relay working with currents up to 20 amperes (Fig. 5). This device, due to Dr. Guy Barr, turns on the fact that an arc cannot be maintained between mercury electrodes in hydrogen. Accordingly, the main circuit is so arranged as to have mercury terminals within the relay, with an

EMPIRE EXHIBITION; METALLURGICAL APPARATUS.

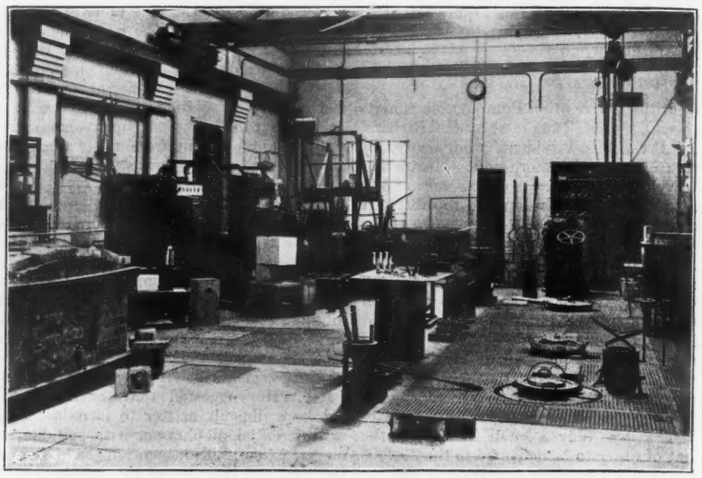


FIG. 1.

FIG. 2.

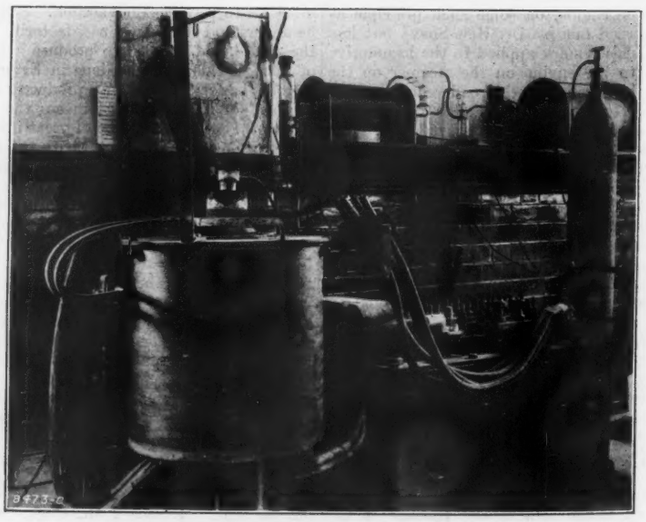


FIG. 3.

atmosphere of hydrogen. The one terminal is provided by mercury within a glass tube, running down the centre of a vertical solenoid, above the top of which the tube has an enlargement provided with a side tube, which serves to admit hydrogen and secure it by being sealed off. In the mercury floats an iron plunger, surrounded at its upper part by a silica cup, also containing mercury; these two bodies of mercury are converted into terminals by iron rods connected with the respective leads. The plunger is the core of the solenoid, and is sucked down when the solenoid is energised by the relay

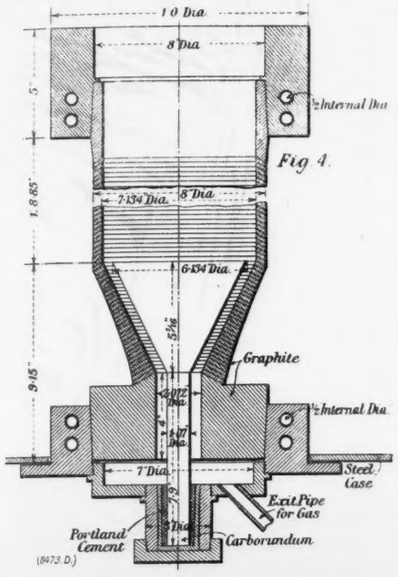


Fig. 4.

dently at a temperature something below what is required. The main flow of gas is controlled by a spherical-faced valve carried by the core of a solenoid under the control of a spring and an oil dashpot. On the thermostat closing the 3-volt circuit through the coils of a Post-office relay with

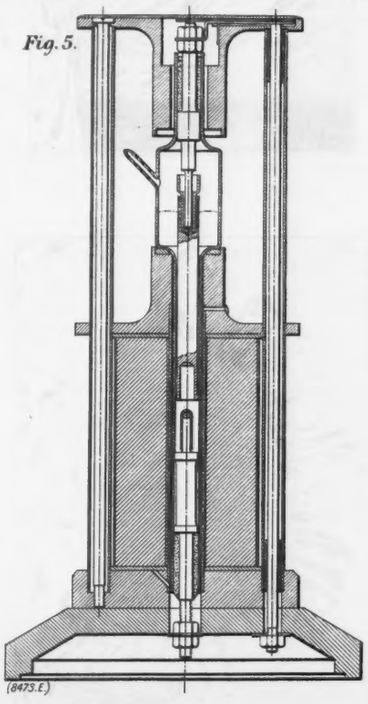


Fig. 5.

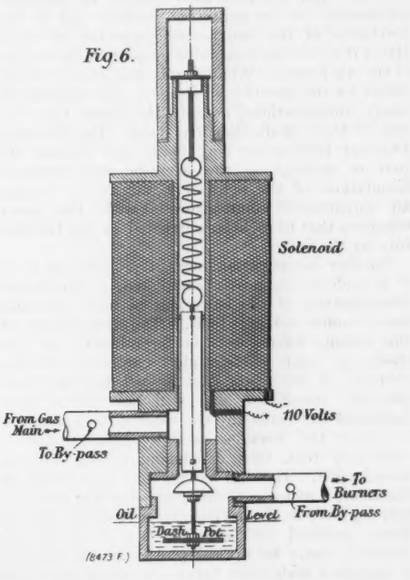


Fig. 6.

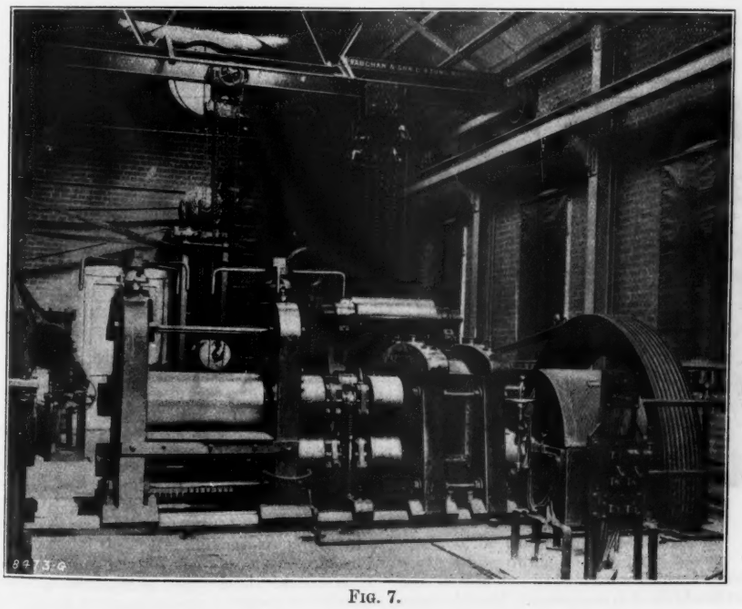


FIG. 7.

Fig. 8.

Fig. 9.

Fig. 10.

current—about 0·03 of an ampere—till the silica cup is submerged. When the relay circuit is broken, the plunger and the cup rise, and the main circuit is broken between the bodies of mercury within and around the cup.

This relay can, of course, be actuated by any thermostatic device that completes and interrupts a relay circuit. One such device has been worked out in the laboratory, depending on the difference in expansion between rods of silica and metal, multiplied mechanically by ingenious arrangements. This device is shown also applied to operate a gas regulator for controlling the temperature of a gas-heated muffle. The regulator (Fig. 6) is provided with a bye-pass, which keeps the furnace indepen-

which it is connected, the relay closes a 100-volt circuit on the solenoid, so causing the plunger to lift the valve up to its seat and so cut off the main gas supply. The temperature of the muffle in this working exhibit is recorded on temperature recorder made by the Cambridge Instrument Company, Ltd.

The Department's equipment includes also a rolling mill, of which a general view appears in Fig. 7. The principal machine is a mill with both sheet (as in Fig. 7) and rod rolls, driven by a 60 h.p. continuous current motor through a rope-driven flywheel and suitable reduction gear, current up to 240 volts being supplied from batteries. The sheet rolls, 15 in. diameter by 2 ft. 6 in. face, will take 1½ plate, and the rod rolls will handle billets 3 in. diameter and reduce them to ½ in. To the left of the mills appear small rolls 4 in. face by 3½ in. diameter which will roll soft metal to 0·005 in. full face or 0·001 in. half face. There are also a pneumatic forging hammer and a hydraulic press. A 4-ton travelling crane is available for all machines.

The exhibits and this description do not include the whole of the Department's equipment; but they are sufficient to suggest the sort of scale of its facilities. They are seen to be sufficient to enable it to reproduce mechanically the conditions of a wider range of metallurgical problems than can usually be undertaken outside a well equipped works, and to attack the problems so defined not only with apparatus but with a combined staff that no works is likely to command. For a further element in the working conditions of the laboratory is that the services of all departments are at the disposal of each of them. The Metallurgical Department has thus been able, while pursuing its own proper work without interruption, either to have work in chemistry, engineering, metrology and physics done simultaneously in the departments specially concerned with those sciences, or to deal with suitable problems by joint investigations.

As in the exhibits that illustrate the equipment of the Laboratory, so in those that deal with the results it has attained, the Department has exercised a commendable reticence, and has put forward not the whole of the results but such a collection as represents its work typically and sufficiently. The most important of these is the research on light alloys, conducted by Dr. Rosenhain, Mr. S. L. Archbutt, and Dr. Hanson, and recorded by them in the 11th Report to the Alloys Research Committee. Samples and data are shown both of cast

and of wrought alloys, illustrating both the results obtained and the stages of development by which they were reached. This research and its results will always be remembered as an example of preparations for scientific work made almost by accident in advance of a great emergency, which proved to be of inestimable value when the unforeseen emergency arose. Notwithstanding the great merit of work that was done elsewhere, the work of the Laboratory on light alloys, done when it was in virtue of the broad-minded spirit in which its equipment had already been laid out, was the most valuable and comprehensive source of practical information on its important subject, and in the revelation of the unexpected properties of these alloys it served an invaluable purpose in the service of the Air Forces. What may be the future of these alloys for the uses of civil industry must depend on many considerations, notably the course that the cost of their production may take. The National Physical Laboratory may justly put forward its part in establishing the scientific and technical foundations of the light-alloy industry as having an importance commensurate with the great resources that have been entrusted to the Laboratory by the State.

Another investigation now in progress, and, as it is understood, nearly completed, is the better determination of the behaviour of mild steel and brass under cutting tools. The conclusions of this enquiry have yet to be formulated; but the specimens and photographs exhibited disclose evidence of distortion that as yet has not been generally recognised, and still has to be both explained and applied. The method used has been to rotate the work—a disc—by hand against a stationary tool, thus developing a chip without detaching it. The disc having then been taken off the lathe, a sector containing the chip has been cut out, embedded electrolytically in copper, ground down, polished and etched. Figs. 8 to 10 are drawings made by optical projection, showing on a magnified scale three types into which the chips have resolved themselves. Fig. 11 is a photo-micrograph of a brass chip of the type shown in Fig. 10, in which the cutting action is seen to be

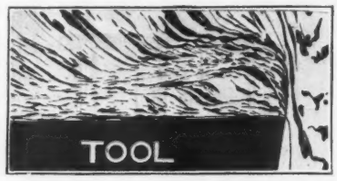


FIG. 11.

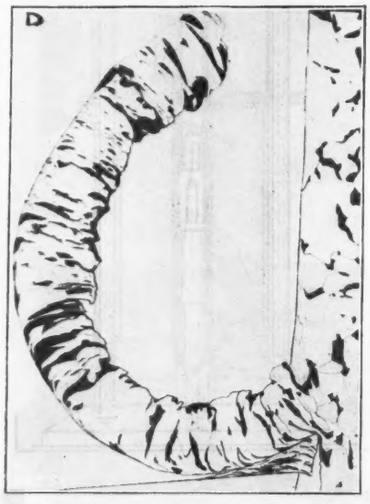


FIG. 12.

FIG. 13.

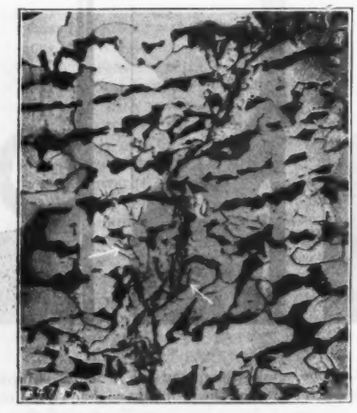


FIG. 14.

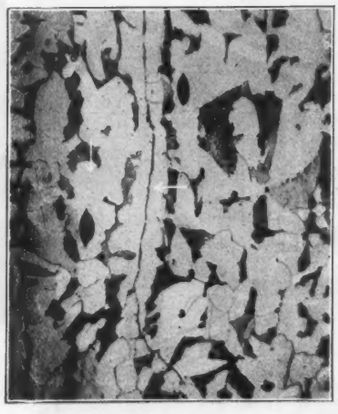


FIG. 15.

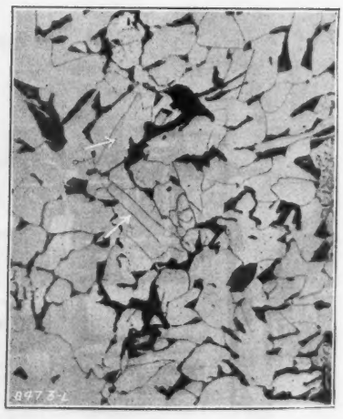


FIG. 16.

accompanied by a remarkable zone of deformation in the neighbourhood of the tool. Figs. 12 and 13 show pieces of such chips in mild steel and brass respectively much more highly magnified, showing the distortion even more plainly. Whether further examination will produce the required explanation and application—what relation circumstances such as the rake and relief of the cutting tool and the physical properties of the metal cut may bear to the formations here disclosed, and whether chips formed at ordinary cutting speeds will have any, and what, relation to these—are questions that doubtless are not answered by the present exhibit; but it indicates that the laboratory is throwing new light on an old subject by an original method.

A small batch of minor but useful results of the work in this department are the refractory pots, most of which were worked out because they could not be obtained in commerce. Notable among them are crucibles in fused magnesia, glazes that will stand temperatures above those at which they were fired, and sheathing that for a short time can stand a temperature of 1,650 deg. C. The importance of the glazes lies in the fact that the muffles coated or impregnated with them are practically gas tight at the highest temperatures they can stand.

An interesting collection is the exhibit relating to "investigation" tests, which means enquiry into causes of failure. Such enquiries are made more often in steel works laboratories than in engineering establishments; but, perhaps as a result, the laboratory receives a great variety of them from engineers, and the exhibit illustrates fairly the methods of attack it has found most useful. As an outcome of this class of experience, it exhibits four types of fracture that in mild steel are found so often in association with definite causes that, when one of these types of fractures is present, it seems to point to the existence of its associated cause. These are shown in Figs. 14 to 17, which represent fractures that respectively seem to arise from tearing, fatigue, shock, and corrosion. By tearing is meant a fracture produced by any kind of overload other than shock or fatigue. It is seen in the photo-micrograph (Fig. 14) by the appearance of slight dark lines in the white patches of ferrite, such as those to which the arrows marked on the figure point. The characteristic of fatigue fracture (Fig. 15) is the lack of distortion in the crystals; and the distortions in the other figures will be recognised more easily if they are compared with the undisturbed white of the ferrite in Fig. 15, as in the areas indicated by the arrows. In shock fracture, shown in Fig. 16, the main cracking

seems to be intermittent, producing cavities that appear in the photo-micrograph as spaces darker than the pearlite, these cavities being presumably connected by minute cracks. The characteristic of shock fracture seems to be the presence of fine bands or lines (Neuman lines), such as those to which the arrows point. Of corrosion fractures there are various types, one of which is shown in Fig. 17. It appears to be wholly inter-crystalline, and is characterised by a network of cracks, which seem to be filled with corrosion products. The exhibition of these types should give an opportunity for comparing experiences, to which the large numbers collected by the laboratory gives theirs a special value.

The individual experiences of the laboratory in respect to fractures are represented by a considerable variety of macro- and micro-photographs showing typical faults in material that has failed. In particular, four sets of micro-photographs are shown, illustrating good and defective structures for case-hardened articles, a marine shaft, boiler plate, and a railway carriage coupling, with sulphur prints of objects such as crank-shafts.

In the Chemical Trades Section is to be seen an exhibit with the not very sensational appearance of a number of large air-tight tins. These represent stocks of millings of standard steels, and illustrate an important function of the Laboratory in helping to standardise methods of analysis, or at least to minimise the mischief of their divergent results. The ingots from which the samples are taken are made

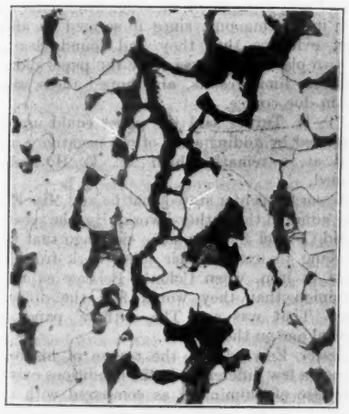


FIG. 17.

with special care, and, after cropping, a large hole through the centre is drilled out, a considerable part of the surface is machined off, millings are taken at several parts with somewhat more than usual precautions against including impurities such as oil or dirt and analysed, and are accepted only if the results are closely concordant. Such millings are sent to a number of different analysts, whose independent analyses have to be in the opinion both of local committees of steel makers and metallurgical chemists and of the Laboratory so concordant as to leave no doubt of the uniformity of the ingot. The whole ingot is then milled up, the fines sieved off, and with renewed verification of the concordance of the coarse millings, are preserved in these tins as standards, and specimens supplied to those who need them. In this way doubts as to actual composition of material that gives different results on different analytical methods can be resolved with certainty; and it may be hoped that in time the use of these standards may help to eliminate methods that experience of this kind may show to be unsatisfactory.

The exhibit in the Non-Ferrous Trades Section consists of specimens and particulars of the results of work done by the Laboratory for the Trade on the effect of impurities on copper. The most striking of these is a series of bars made of copper with various small percentages of impurity, of which the lengths are proportional to their respective electrical conductivities. As compared with copper containing 0·015 per cent. of oxygen, with a conductivity of 102·1 per cent., the presence of 0·36 per cent. oxygen reduces the conductivity to 96·2 per cent. and while the presence of arsenic 0·053 per cent. gives a conductivity of 85·5 per cent., increase to 1·04 per cent. brings it down to about one-fourth of that figure, or about a fifth of the conductivity of pure copper. No better suggestion could be made of the value of quality in manufacture, which the non-ferrous trades are leaving no measure untried to raise and to standardise.

THE IRON AND STEEL INSTITUTE.

(*Continued from page* 616.)

THE proceedings which we reported in our last issue were continued by the reading and discussion of the papers according to the programme.

CONTINUOUS ROLLING MILLS.

The first paper taken on Thursday morning, the 8th inst., was entitled "Continuous Rolling Mills: Their Growth and Development," by Mr. J. P. Bedson, who read it in abstract. We reproduced it in an abridged form on page 620 *ante*.

The discussion was opened by Captain L. D. Whitehead, who said he had been greatly interested in the historical review given by the author. Dealing with one detail part he stated that the old Staffordshire wobbler was still by far the best. He found that to apply to this country a specialised American mill was not a sound commercial proposition. In this country he did not think a continuous mill would pay if installed inland; it must be so situated that it could be fed easily both with home and foreign billets.

Mr. G. E. Falck, speaking in French, said that in Italy the question of continuous mills such as were referred to in the paper was being followed with the greatest interest. The difficulty, however, was that few works had a cogging mill installation, and the Italian ironmasters had been considering whether the difficulty could not be overcome by starting directly from the ingot. He (the speaker) had gone into the matter for certain works, and had visited a plant in Polish Silesia where he had seen rolling being done starting from 7 in. ingots. The ingots were heated in a continuous furnace and were then passed through a series of rolls, shears forming part of the equipment for cutting into billets. The first shears had since been done away with and the material was now sheared after it had passed the later rolling stages. Rolling from ingots directly was therefore possible. But in Italy they were endeavouring to start from a larger ingot. The Denain et Anzin works in France were doing so. Five billets would be formed, and he did not think there would be any risk in a continuous mill of the later billets being too cold for rolling, since the third was sometimes hotter than the first.

Mr. T. W. Hand stated that he wished the paper had contained more data on the operative side. The author had said that to-day in America 30 per cent. of the rolled products were rolled on the continuous system; in this connection it would have been interesting to know what were the particular sections and the range of products. In America the continuous billet mill with the cogging mill was practically universal, the mills being in line. With reference to the author's demonstration that it was possible to roll a billet direct from an ingot and, with the initial heat, to finish it into a No. 8 wire rod, he (the speaker) asked whether this was worth while owing to the large amount of risks involved in the shape of roll breakages. In his own opinion it was a moot question as to whether the mill was the more important, or its auxiliaries. It could be said that the auxiliaries had made mills what they were, for the rapid handling of the material rolled was a most necessary feature. The author had given the example of a mill the operating staff on which numbered five men in all; it would be interesting to know the entire labour cost the manufacturer had to meet. The author's list of six continuous mills had to be supplemented by six more, there being 12 throughout the country. There was scope for more still, and if a larger number were put down it would bring down the cost of billets.

Mr. J. D. Ellis, in regard to rolling rods from the ingot direct, said this was being done at a small works at Libau in a small Belgian mill. The ingots passed through a continuous furnace to the cogging mill and from the shears to three looping mills. The ingots were cast on the spot at the same works.

In the course of his reply, Mr. Bedson said a continuous rod mill required a large amount of attendance, since a section in course of rolling held itself up, whilst in a rod the difficulty was to get it to stand up. He gave in his paper examples of the satisfactory rolling of an ingot into blooms, the material proceeding to the looping mill, and had said, as early as in 1885, that it was possible to do so on the initial heat of the ingot. He agreed entirely that unless very complete auxiliaries were available from start to finish to deal with the product, an installation would be quite unsatisfactory. The men he had mentioned, five in number, were the actual men on the job distributed as he had stated. He was glad to find that there were more continuous mills in this country than he had stated.

DEFORMATION OF α AND γ IRON.

The first paper taken on Thursday afternoon, Professor Carpenter occupying the chair in the absence of the president, had reference to "The Plastic Deformation of Alpha and Gamma Iron," by Professor F. C. Thompson and Mr. W. E. W. Millington; it was read in abstract by the latter.

The paper was divided into two parts, the first dealing with γ iron. It referred to a paper read by the same authors dealing with the fatigue of α brass (see pages 344 and 353 *ante*); and stated that the space-lattices of the brass and γ iron being both close-packed cubic arrangements, the work done on the brass was similar to that done on γ iron. For purposes of completeness the method had been extended to the more open-packed structure of α iron. The authors illustrated their paper by structures they exhibited made up of ping-pong balls. They explained how, when a stress was applied to the cubic packing, so as to cause shear, the first effect was to induce movement such that an atom, as illustrated in a model, was caused to glide over into another position. This was styled an "easy glide." This easy glide accounted for the twinning in austenite and to a certain extent for the formation of martensite, though the authors did not agree altogether with the term "twinned austenite." Another interesting model of the authors' was one depicting crystals, and showing how the slip-bands were formed under stress.

COLD-WORK AND DENSITY.

The above paper was taken together with one on "The Effect of Cold-Work upon the Density of Crystals of α Iron," by Mr. Hugh O'Neill, who read it in abstract.

The author stated that if an aggregate of crystal of α iron be increasingly cold-worked in tension, the mean density, whilst at first showing only small alteration, soon decreased by about 0·17 per cent. It then appeared that a critical amount of deformation was reached at which the density ceased to fall, and might rise slightly. With further increments of cold-work, the density decreased. The results for a test-piece of Armco iron were shown graphically, the overall fall in density being 0·83 per cent. The density of a single crystal deformed by cold work differed considerably from an aggregate deformed in the same way.

Dr. Rosenhain said the theory that had been put forward so clearly and ingenuously by Messrs. Thompson and Millington was not new; they had heard it explained by the same authors at the Institute of Metals meeting a few weeks ago. The present paper could not be said to complete the former one. In his (the speaker's) opinion, it was a serious matter to base an elaborate theory upon the geometry of piled ping-pong balls or other spheres. It was not right to carry atomic speculations to anything like the length to which they had been carried in the present instance. Physicists were unanimous in stating that it was quite wrong to suppose that atoms behaved in the least degree like spheres in contact. In regard to "easy-glide," if it occurred, there would be, he supposed, no appearance of slip on the surface, no slip bands would be formed.

If "easy-glide" occurred before slip took place, then there must be a large amount of permanent deformation of the metal before slip bands begun to occur, but slip bands began to occur as soon as the elastic limit, as measured by most delicate instruments, was passed. The authors had explained why the cube-centred α iron did not twin, whereas the face-centred α iron did. But there was one metal, a face-centred cubic metal which did not twin, namely, aluminium. An investigator had obtained photo-micrographs of α iron, which was full of twins; but he (the speaker) was not altogether in agreement with that investigator. Dr. Rosenhain could not conceive a layer of atoms lying balanced on the top of a pile, such as the authors had shown, for any length of time under any conditions. It was a condition of maximum potential energy, thermo-dynamically unstable and bound to change; but if it did remain there would be an entirely different packing of the atoms. Dr. Rosenhain took a more sympathetic view of the authors' theories in regard to slip-bands; the section of their paper dealing with these was the most interesting part. Those theories stood alone and would prove of greater permanent value than the other theories of the authors'. Dr. Rosenhaim here drew a diagram pointing out that there was a space between the atoms, and there was room, as Dr. Westgren had shown, for carbon atoms in between the atoms of the γ iron lattice.

Colonel Belaiew said some of the authors' deductions could be reconciled with previously ascertained facts. Most of their deductions, if not all, could be reached also by other methods. They used balls so that their theory could be more easily followed. From the purely geometrical point of view, the drawings in the paper made from the models merely gave the geometrical relations of some of the angles, and could be justified by mathematical deductions. The idea that atoms behaved like hard spheres was a very old one. The kinetic theory of gases was built up on the assumption that gaseous molecules behaved like spherical hard balls. Here Colonel Belaiew considered the hydrogen atom, which was built up of two electrical charges, and explained its behaviour by a diagram. It seemed to him that there was substantial evidence to explain why the authors' simile was a sound one; but space had to be allowed between the balls, and he (the speaker) thought that this was of a nature to invalidate somewhat the authors' theories. The matters dealt with could be tested by the X-ray method. Another way was to find a substance that would crystallise like α iron in the cube-centred lattice and to try to see by a sudden deformation, or by the method of secondary deposits, what the planes would be.

Professor Edwards asked whether the authors' idea of "easy-glide" was the only one. In regard to Mr. O'Neill's paper, hesitation should be shown in applying the data he had obtained. The differences the author pointed out were remarkably slight, and he was not dealing with pure iron, but with iron containing 2 per cent. of silicon, which must alter any particular kind of movement that occurred on a gliding plane.

Miss Elam's chief objection was that the evidence, such as there was, as to change of crystal structure during straining, was in absolute disagreement with the authors' theory. Any movement such as the authors had described would lead to the breaking up of the crystal structure or to the formation of twins if the movement were completed. Neither had been found in X-ray measurements. If the crystal were face-centred cubic, it remained so whatever was done. The authors had said that in the close-packed cubic metals the slip bands were in general very straight, due to the fact, as Miss Elam had pointed out, that they were really Neumann lines. She (the speaker) was sure she had never said that all slip-bands were Neumann lines. She disagreed from Dr. Rosenhain since she had obtained some very nice twins in aluminium.

Dr. Hatfield thought that until physicists were more certain as to the nature of the atom, it was too early to build up elaborate theories as the authors had done. The latter had said that certain metals behaved differently under certain suddenly applied stresses from under, say, static effect, and he would like them to give actual examples of such differences. Were not the authors confusing shock with notch-bar tests? The authors had said that temper-brittleness was due to the precipitation of something from solid solution during the slow cooling of the steel; he (Dr. Hatfield) disagreed with this precipitation theory. But his own view was that the explanation of temper-brittleness, when more was known about the atom, might perhaps be explained by some geometrical movement of the kind the authors had shown. Dr. Hatfield agreed with Professor Edwards, in regard to Mr. O'Neill's paper, that it was unfair to make deductions as regards pure iron from iron to which silicon had been added, as silicon had a far-reaching effect.

Dr. Hanson thought the authors would agree that in its present stage their theory was speculative. It seemed to him that their theory both as to α iron and γ iron rested on the assumption that slip could take place in certain directions in the crystal. In the case of γ iron he had evidence to show that slip would not always take place on octahedral planes, which did not agree with the authors' statement as to the mechanism of yield and the end of yield in α iron; nickel was a pure metal which crystallised in the face-centred cubic form and had a much bigger yield than iron. In regard to fatigue, the straight lines in his (the speaker's) experiments were produced in profusion within the fatigue range.

Mr. Saniter, dealing with Mr. O'Neill's paper, did not find the title a suitable one; the paper dealt with tension stresses and not adequately with compression stresses. In the analysis of Armco iron many other figures should also have been quoted. The author spoke of a yield halt in gauge, at 7·6 tons per sq. in., did he mean the limit of proportionality, or the elastic limit, or the yield point? If the latter, it was a very low figure.

Professor Thompson in replying said that after the remarks by Colonel Belaiew it was hardly necessary for him to deal with the question of the atom. Some speakers might have given them (the authors) credit for realising that the atom was not a ping-pong ball or anything like it. They (the authors) had said as much. The question of the real physical nature of the atom had been gone into very carefully and his (the speaker's) experience with that of the staff of the Physical Department of the University of Manchester had been diametrically opposite to that of Dr. Rosenhain. Continuing, Dr. Thompson said that if one cared to call the ping-pong balls the spheres of repulsion of one atom for the other he took it that it was possible to place the matter on absolutely definite physical grounds. The number of facts they had been able to explain which had not been explained in the past was strong confirmation of the satisfactory nature of the method they had used. The authors' idea of slip-bands was derived after they had carried out the rest of their work and on exactly the same lines as the rest of their work, *i.e.*, by "playing about with balls." The "easy-glide" movement on the octahedral plane applied not to α iron at all but to γ iron. He (the speaker) disagreed with Professor Edwards' reference to Mr. O'Neill's paper, and although the silicon in the iron rendered the results less interesting and important, the probability was that the similarity between the crystallographic behaviour of the material and of pure iron would be very great.

Mr. H. O'Neill, in reply to Mr. Saniter, said the 7·6 tons per sq. in. was the yield point, given when the beam dropped.

The Production of Large Crystals.

The third paper taken on Thursday afternoon was on "The Production of Large Crystals by Annealing Strained Iron," contributed by Professor C. A. Edwards and Mr. L. B. Pfeil. It was read in abstract by the latter. We reproduce it in an abridged form on page 651. The paper was complementary to the one on coarse crystallisation in stampings, which we reproduced in abstract in our issue of September 28 last.

Miss Elam said she had spent much time on work of a similar nature and had not obtained as good results as the authors. She could confirm their observations particularly in regard to the crystal size. A large crystal was not always easily found because the strain was not uniformly distributed. Bars of aluminium often showed streaks, but save from a few exceptions the streaks could be removed by annealing. Crystal growth took place to a considerable extent in aluminium; large crystals were not so easily produced when the sheet was thicker. She did not find the orientation in the crystal produced with the method used by the authors followed any rule; there might even be said to be almost any orientation.

Dr. D. Hanson found the authors' worked ranked in importance with that by Carpenter and Elam on aluminium. He questioned the authors as to the removal of the carbon from the specimens and as to the difference which carbon made; also, how the authors estimated the carbon in the decarburised iron. This was difficult to estimate at all when the percentage was so very low. It was difficult to arrive at a reliable figure; what value did they attach to that very low percentage?

Mr. M. O'Neill referred to a paper published in 1905 by Osmond and Frémont, dealing with the investigations of the properties of large crystals of iron in a rail (a furnace backstay) and with the method of producing them similar to the authors'. He explained the treatment which the rail had been made to undergo and the planes along which fracture occurred. The authors' value of from 9 to 10 tons per square inch were low as compared with Osmond's 17 tons. But Osmond's was applied in a different plane, which would explain the result, as he (the speaker) did not think the actual difference between the two examples was in reality very great. The authors' Fig. 20 of cleavage fragments was a very interesting one, since it seemed to afford distinct evidence that they had found cleavage along two planes. He was sorry the paper did not give elastic limit results, and hoped these would follow in due course.

Mr. T. H. Turner said the paper could usefully be extended by adding some of the negative results arrived at, a remark which Mr. E. H. Saniter confirmed.

Professor Carpenter stated that he and Miss Elam greatly admired the authors' work. He (the speaker) had told Colonel Belaiew some time ago that they were going to extend their joint work from aluminium to iron, when Colonel Belaiew expressed the opinion that they would find the difficulty greater. That was so. The authors' paper was a classical one on the subject.

Professor Edwards, in the course of his reply, explained a few differences in the conditions existing in the case of aluminium as compared with iron. In regard to the carbon, this was removed until no trace of it could be seen under the microscope. In regard also to the carbon this was not in solid solution, whereas phosphorus and manganese were, and comparatively large amounts of these could be in solid relation without interfering very materially with the results. It was difficult for him to reply in the matter of Osmond's work; the difference in their (the authors') figures and those of Osmond might be due to the different analysis of the materials. Tests were now in hand for determining more fully the mechanical properties. With reference to the negative results, there were so many that their account would have resulted in an unduly long paper.

Recovery of Waste Heat.

The first paper taken on Friday morning, the 9th inst., dealt with the "Recovery of Waste Heat in Open-Hearth Practice," contributed by Mr. W. Dyrssen, who read it in abstract.

The paper gave a complete heat balance of fuel for a modern American 80-ton producer-gas open-hearth furnace. The balance showed that in good practice the waste gases from the chequer chambers contained about 43 per cent. of the heat in the fuel, and that by the use of a waste-heat boiler about 25 per cent. of the heat in the fuel could be recovered in steam. It indicated that by insulation of the chequer chambers and flues, by using valves with a small amount of water cooling, and by preventing an excessive amount of air from entering the chequer chambers and flues, the steam output could be raised to correspond with about 34 per cent. of the heat in the fuel. In the case of producer-gas, the elimination of the gas chequer chambers was

considered. The paper discussed the purposed practice of taking part of the waste gases from the melting chamber direct to the boiler; it was shown that the heat in the waste gases from the melting chamber was far in excess of that required for pre-heating the air and gas. The paper gave a heat balance for a producer-gas open-hearth furnace and for a coke-oven gas-fired one. It discussed the use of economisers, &c., and also gave sectional illustrations of gas and air ports and of a three-pass horizontal chequer chamber.

Mr. A. Lindsay Forster said that the advantage of the method described was very interesting to those who had ample scope for the use of additional steam. The inefficiency of the furnace itself was really the point that was giving concern at the present time. For the problem of utilising the available heat in the furnace, one came across the difficulty of obtaining refractories that would stand up to the heat, and if better refractories were available one would not be obliged to have recourse to water-cooling to anything like the extent which now had to prevail. The author had given a table in which he compared ordinary good practice with excellent practice in the working of an open-hearth furnace, and Mr. Forster asked whether his "excellent practice" did full justice to the present-day open-hearth furnace. The author was perhaps not doing full justice to modern open-hearth furnace practice, and not giving full credit to the modern gas generator. He added, however, that they were not now making use of gas generators in the United States, and that would perhaps influence his figures. The author's producer gas was reaching his furnace at 760 deg. C.; he did not say how much carbonic acid was in the gas. The paper was an invitation to consider the application of waste-heat boilers to the furnace. What was the temperature of the gas he used to arrive at that temperature? Was it 900 deg. C.? If so, it was very hot. The author had a comparatively high final gas temperature, in the chimney; there were also several differences following various conditions, all of which would require careful analysis. Some differences were only traceable to actual working; it was perhaps not so much constructional changes that were wanted, as better working and better governing of the furnace. The author had aimed at conserving sensible heat and added so many thermal units to the gas. Better combustion inside the furnace was what all aimed at. He (the speaker) believed the author was the first to give the amount of heat that could be thrown away by excessive cooling; he had recently been interested in the development of a valve in which there was no water-cooling. But one could only too easily be led away by a possible complication in order to overcome a difficulty for counteracting which recourse might be had to easier methods.

Mr. B. Talbot found that some of the members would hardly agree that there had been no saving of fuel in the open-hearth furnace during the last three years. The author had referred to standard open-hearth furnace practice in the United States and he had not alluded to the duplex process, fed by Bessemer metal. Such furnaces could not consume one-half what was consumed in the standard practice. He (the speaker) would like to have more details of the gas and air-ports fitted to the American furnaces. Referring to one of the author's tables (item 23, heat lost in cooling water), we did not lose in this country 13·3 per cent. of the heat in the fuel through these ports on the incandescent side of the furnace. Much had been heard of the American three-pass chequer chambers, and he (the speaker) would like to know whether they were being used largely in the United States and whether they were a success. In the matter of coke oven gas which the author mentioned, Mr. Talbot hoped that was the coming fuel for the open-hearth furnace. It was perfect for the work so long as it did the work satisfactorily in the furnace. He took it that gas was stripped of its benzole. Was it used in the United States by itself? It was true we now had the mechanical producer; it was a better working machine and we could now use its gas better than in the past, but we should probably have to put the producer quite close to the furnace. If that were the case, it will mean practically the rebuilding of our steel plants. If the gas went in directly, then there would be a surplus, and some would be available for steam raising in boilers; one ought perhaps to do something else with it, but undoubtedly it could be used for steam raising. The author had shown the net gain per boiler horse-power month on the operating cost of the boilers per ton of steel, varying from 0·14 dol. to 0·24 dol. That was an important saving, which we could not neglect with our expensive coal. In his opening statement, the author said he considered the open-hearth furnace as being, thermally, a very inefficient apparatus, and in doing so he confirmed his brother experts in the United States. He had also stated that in order to reduce the fuel consumption per ton of steel efforts must principally be made to produce more steel per hour, *i.e.*, to increase the size of the heats or reduce the time per heat. Mr. Talbot entirely agreed with this latter statement, but he did not want the size of the ladles to be increased correspondingly with the size of the furnace. Such an increase would exercise the capacity of the furnace designers, seeing the shallow bath that was necessary for steel making.

Mr. J. E. James questioned the author as to the three-passage device he had referred to and asked whether this was in general use in the United States; what was its life, and where did he obtain his bricks. In regard to the introduction of cold air in the off-takes during the time the heat was at its highest, he was afraid the steel makers would be found averse to being robbed of that finishing touch which they could turn to account for making the steel satisfactory. Was that part of the process under the control of the steel maker? The economies which could be effected, as pointed out by the author, were duly appreciated. In the paper an attack had been made upon the gases escaping from the furnace; where the waste was greatest pointed to the direction in which the greatest possible saving could be effected. Our attention could be directed to the gas consumption, leading to the cutting-down of the coal consumption and to a consequent increase in efficiency. He (the speaker) felt at a loss to understand whether the author had spoken of future developments, or whether the arrangements he mentioned had really been tried, and were not the outcome of many possibilities which occurred to all. In one of his (the speaker's) experiments, waste took place, the temperature fell, the flame lengthened out to the length of the furnace.

Mr. H. M. Ridge thought the conditions which prevailed in this country could not be compared with those in the United States. One of the losses in the United States was due to water cooling, whilst here we did not have water cooling to the extent used in America. The American Ingalls had said that a metallurgical furnace should be used as such, not to raise steam, except the very minimum. If used for steam raising there was the danger of depending upon the furnace operation for steam raising. It was better to see how the furnace conditions could be improved irrespective of raising steam. One most important point brought out by the author was the small amount of heat used in the open-hearth furnace for its proper work. The heat intensity should be increased by heating the air to the limit possible with the available refractories. The author's figures were the first detail figures given for the losses of heat at various parts of the furnace by radiation, and the meeting was indebted to him for splitting them up as he had done, instead of giving simply a total. He hoped the author would also give the figures making up the 760 deg. C. temperature of producer gas to furnace. He asked whether the author had been able to use the three-pass chequer chambers satisfactorily; he (the speaker) did, but it was not convenient to do so where the temperature was about 1,300 deg. He doubted whether they could then be satisfactorily used. In this country we might do better, in order to reduce fuel consumption, to improve our regenerators and use better refractories, avoiding waste-heat boilers.

Mr. E. H. Saniter queried the author's statement to the effect that the expenditure for the alterations he dealt with was well warranted, since in a modern open-hearth plant making yearly about 1,000,000 tons of ingots, the saving, the author had said, might be as high as 800,000 dols. per year. This statement in itself he found very bald; much had no doubt to be put against it. He (the speaker) looked for economy in getting more steel than more steam. Mr. Saniter found the author's temperature of the waste gases at the chimney very high.

Mr. F. W. Paul said conditions differed when the producers were in close proximity to the furnaces and when they were at a distance; in some cases steam got into the gas and condenser. It was feasible to work the regenerators without reducing the gas in the chequers; he had done so without loss of heats. The question of hydro-carbons in the gas also came in.

Dr. Rosenhain stated that the temperature and length of flame was not a function of the temperature of the gas or air, but of their mixture. Much depended upon the velocity of the gases. Acceleration of the velocity of the gases had been pushed to the limit in an American plant; the air was blown through. It was hard on the furnace and ports, but an intense flame was produced down on the bath and the rate of melting was improved. There were large heats per day and a larger number of heats per life of the furnace. For heat insulation the remedy was simple. The main object of the furnace was to make steel, and that should be kept in full view. Whether to use regeneration or not depended on what the gas was.

Mr. O. Frick asked how the author ascertained his radiation losses.

Dr. W. H. Hatfield found the author's paper to have the merit of much originality in outlook. When the author indicated a percentage loss of heat through water-cooling that was the price paid for something that was valuable. If economy were made by reducing that loss of heat it might occur that one lost more than one gained, looking at the question from the point of view of maintenance. He (the speaker) did not think there was a danger of works operating large steel plants looking upon them in the light of steam-producing plants. There was much surplus heat that could be turned to account and room for the excellent use of waste heat boilers. He considered that the quality of the open-hearth furnace structure, and making it a gas-tight structure, was the direction in which one should concentrate for improvements. An imperfect structure, one insufficiently strong led to very heavy losses throughout the process.

Here Mr. E. K. Scott exhibited a diagram of the Lopulco system of steam raising which could be used with gas or pulverised fuel, but this was considered to be outside the subject under consideration.

Mr. W. Dyrssen thanked the meeting for the good reception given his paper, and said he would reply by correspondence.

(To be continued.)

420-H.P. ELECTRIC WINDER.

A VERY good example of a single drum colliery winder, which is electrically driven through single reduction gearing, is provided by the 420-h.p. equipment exhibited by Messrs. Vickers, Limited, at the British Empire Exhibition. The brake-operating gear has novel features, both in the method of release and control and in the arrangement for the compensation for wear of the blocks.

The motor is of the protected slip-ring induction type with bearings of the adjustable bracket type, which have been specially designed for use on motors of this class to combine the best features of both the pedestal and the plain and shield designs. The machine is wound for connection to a three-phase supply at 3,000 to 3,300 volts and 50 periods. It has ten poles, and runs at a full load speed of 565 r.p.m. When run at its rated full load of 420 h.p. for six hours, the temperature rise does not exceed 40 deg. C. On occasions very heavy torques may be exerted by it, reaching to twice the normal full load value. On test the full load efficiency of the motor was found to be approximately 92 per cent. and the power factor 90 per cent. Between the end of its shaft and the pinion shaft a shock-absorbing coupling is provided to carry the drive. The pinion is made solid with its shaft. A ratio of 9·6 to 1 is obtained through the single reduction gearing, which has machine-cut double helical teeth of the type common in steam turbine drives, and is completely enclosed within an oil-tight sheet steel casing. From the gear the drive is taken directly to the substantial winding drum. The lay-out of the general equipment is clearly indicated in Fig. 1, on the next page. The control platform is not shown as its presence would have obscured the view of the brake engine, the

420-H.P. ELECTRIC WINDER AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. VICKERS, LIMITED, ENGINEERS, BARROW-IN-FURNESS.

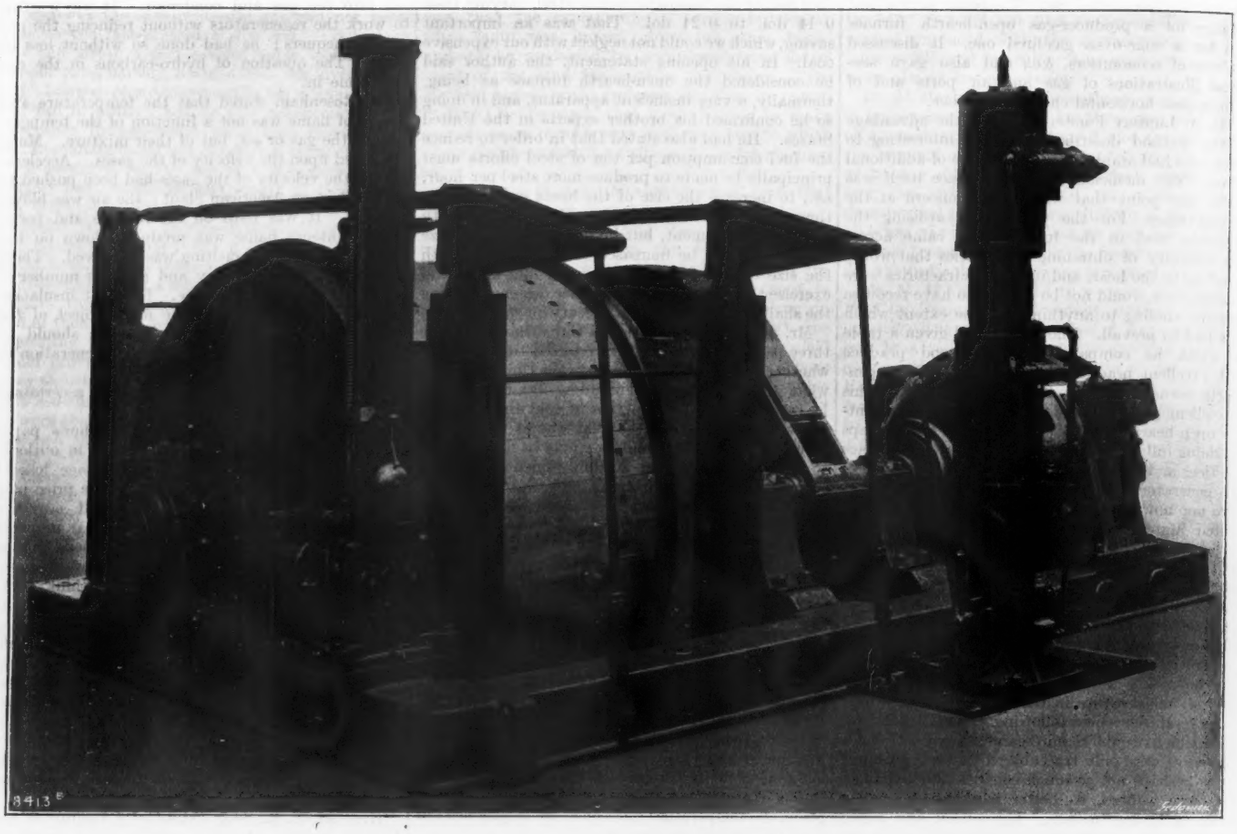


FIG. 1. GENERAL VIEW WITH OPERATING PLATFORM REMOVED.

depth indicator, and other features to which it is desirable to draw attention.

The brakes are of the anchored post type in duplicate, that is to say, there are two sets of brakes and they act upon the brake rims at each side of the drums. Both systems are operated from a common weigh shaft, the motion from which is taken through radius arms and connecting links to frame structures with triangular sides above (see Fig. 1). These frames are arranged so that motion is given to the blocks on each side of the drum at the same time. An automatic take-up gear compensates for any wear of the blocks and ensures that both sets are applied together and take an exactly equal share of the load. The actual motion for the weigh shaft is obtained from the fall of a heavy weight hanging from the end of a long arm which is keyed to the weigh shaft. This loading system is erected immediately below a hydraulic cylinder from the motion of the piston of which its release and control is obtained. For this purpose the piston rod of the brake engine is extended downwards and the weight is suspended from it, with the interposition of a helical spring to steady up the action. When the brakes are to be released, oil or some other suitable liquid is introduced beneath the piston of the engine under sufficient pressure to lift the load. By means of a motor-driven pump the liquid is always kept at the required pressure, and as an ample supply for many charges is required, the delivery side of the pump is connected to a pressure tank of large capacity. The movement of a simple slide valve is used to control the operations. There are on its seat three ports, the bottom one of which communicates with the underside of the piston and allows the admission of oil to relieve the brakes, while the top one is connected with the other end of the cylinder and permits the use of the oil pressure to augment the action of the falling weight, when it is necessary to apply extra pressure in an emergency, and the middle one communicates with the pump suction sump. A floating lever gear is provided to communicate the motion to the valve from a hand lever on the driver's platform. Whenever the hand lever is moved the valve opens, but it is so arranged that it automatically closes when the piston has moved through the distance corresponding to the travel of the hand lever. The speed at which the control weight falls and applies the brakes is dependent on the area of port opening given by the valve; meanwhile the liquid below the piston is passed to the exhaust port. To prevent the sudden application of the brakes when running under normal conditions, and so keep down the shocks and strains on the whole system, a moderate limit is fixed for the normal speed. For abnormal conditions much more rapid action is desirable and consequently a quick-braking device is provided, which consists of an auxiliary bye-pass valve fitted in the bottom supply port of the brake engine cylinder. This is operated by a solenoid, which becomes energised only when the winder is running at high speed as its load approaches the banking level. The release of a catch then causes the auxiliary valve to be opened, giving an increased exhaust port area and causing an accelerated application of the brakes.

In addition to the lever for operating the brakes and the controller for the motor, there is provided on the driver's platform an emergency lever which normally is situated in a vertical position. When pulled towards the driver rapid braking is effected and the motor is shut down by this single action. This is effected by the tripping of a catch which releases a weight and on falling this operates a switch which cuts off the current supply to the motor while other gear provides for the operation of the brake engine valve independently of the main brake lever. Failure of current can cause no trouble, for in that event the brakes are applied by the release of gear normally held in position by a solenoid, which is mounted on the driver's platform. The emergency trips are so arranged that they cannot be reset unless the main brakes are put into action. Machine-cut gears driven from the drum, shown at the top of Fig. 3, give motion through bevels to two vertical screws carrying nuts with pointers travelling over an upright scale. Whatever position the pointers take up corresponds with the depth of the cages in the pit shaft. This depth indicator, shown clearly in Fig. 1, is thus positively driven from the drum and is of a sturdy and serviceable type. When the winding limits are reached, the travelling nuts of the depth indicator come in contact with a switch which prevents overwinding or starting in the wrong direction. Any motion in excess of the normal actuates the switch and cuts off current from the motor, and the brakes are instantly applied by the solenoid gear, already referred to, which comes into action on the failure of the current. Other fittings, in the form of skates on the indicator nuts, operate switches which can be adjusted to such a position on the indicator as to correspond to the places at which the slowing down is necessary to land the cage exactly at the proper level at the bank. These switches energise a solenoid and bring the brakes into action. An overspeed generator and rheostat are driven off the pinion of the gear, and the depth indicator respectively to ensure the maintenance at all times of suitable speeds. From what has been said of the safety drives and control arrangements it will be clearly appreciated that every possible contingency is provided for, and the maximum of safety in working under all conditions has been the aim and achievement of the designer.

EXTENSION TO THE IMPERIAL TELEGRAPH SYSTEM.—The cable ship Faraday left the Woolwich Works of Messrs Siemens Brothers and Co., last Wednesday, the 7th inst., laden with a large quantity of submarine cable manufactured by the company, and destined to form the extension of the Imperial Telegraph System connecting Turk's Island with Barbados, Demerara and Trinidad. The whole of the work is expected to be completed in June.

THE HANDLING OF GOODS.—Messrs. Davidson, Park and Speed, Limited, Waterloo Chambers, 19, Waterloo-street, Glasgow, say that they have been asked by numerous traders to assist them in the difficulty of arriving at accurate costs of handling goods from ex-ship to destinations. They have, therefore, prepared a complete list of inclusive charges from ex-ship Glasgow, Leith, and Grangemouth, to delivery in all important Scottish towns. They will be glad to supply a copy to any of our readers on application.

420-H.P. ELECTRIC WINDER AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. VICKERS, LIMITED, ENGINEERS, BARROW-IN-FURNESS.

(*For Description, see Page* 633.)

Fig. 2.

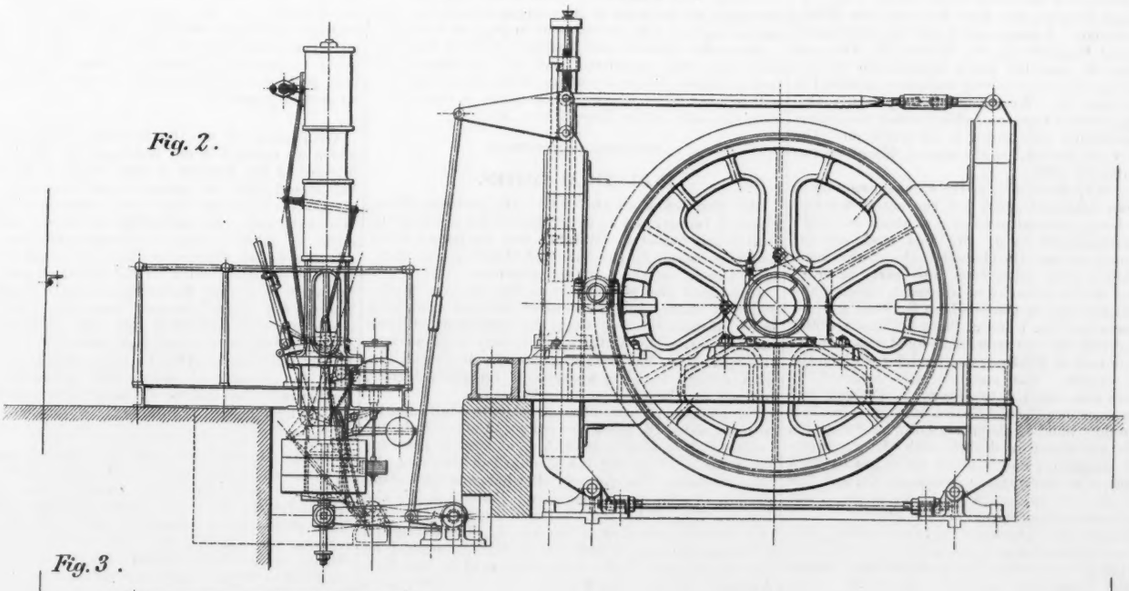
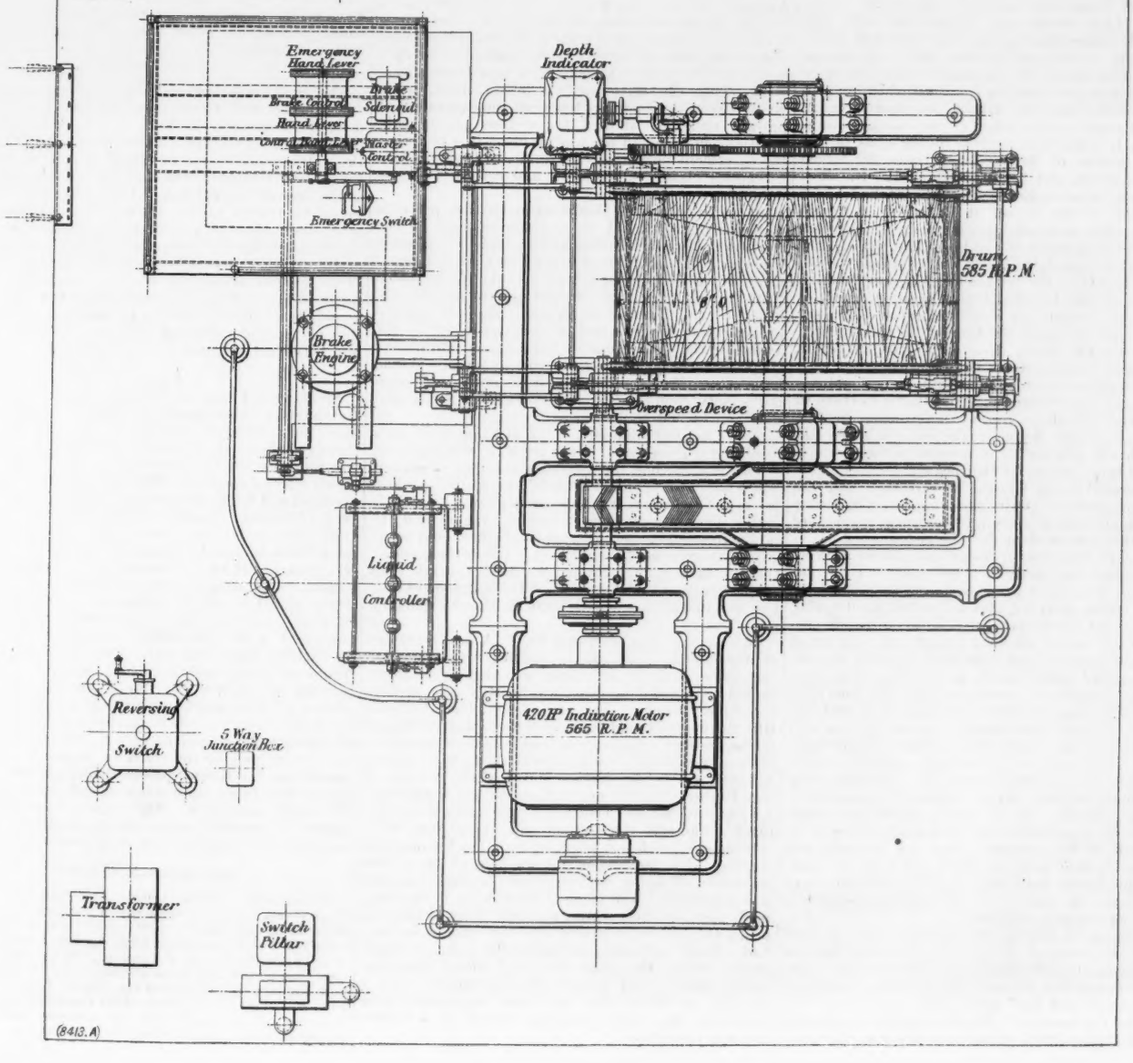


Fig. 3.



200-TON DRAGLINE EXCAVATOR FOR THE SUDAN.

THE demand for cotton growing within the Empire has led to the undertaking of one of the greatest irrigation schemes of the world in the Gezira, a tract of land enclosed between the Blue Nile and the White Nile in the Sudan. A paper read before the Institution of Mechanical Engineers by Mr. Richard W. Allen, on Friday, May 9, provided much information on the general scheme and on pumping machinery installed in connection with it. We commence reprinting this paper on page 654 of this issue, while further particulars of the undertaking were given in an article on "The Irrigation of the Sudan," in the issue of ENGINEERING for September 29, 1922.

The area to be dealt with in the scheme amounts to no less than 3,000,000 acres, but the initial developments are being confined to an area of about one-tenth of the contemplated total. For this work the excavators must combine the characteristics of sturdiness and reliability with subdivision into parts of small weight, due to the necessity of transport, erection and possible dismantling in places where facilities are few. We illustrate in Figs. 1 and 2, Plate LXII, a recently constructed 200-ton excavator, built by Messrs. Lobnitz and Co., Limited, of Renfrew, Scotland, for work on the irrigation canals. The machine was designed by the builders and supplied to Messrs. S. Pearson and Son, the contractors for the Gezira scheme. In their work as dredger builders Messrs. Lobnitz have acquired a valuable experience in dealing with the exceptionally heavy conditions under which plant has to work in the removal of obstructions in waterways, and this has been put to service in designing some of the features of this interesting excavating plant.

This dragline excavator has a bucket of 5 cubic yards capacity and is mounted on four trucks of the equalising type, so that at times when the wheels are on an uneven surface the frame still remains horizontal. Each truck has four wheels and is provided with ball and socket centre bearings, so that they can easily accommodate themselves to travelling on curves. The rails over which the excavator is run are lifted by the machine and reset in front with little expenditure of either time or labour, so that progress is made as rapid as the other circumstances permit. The boom is connected directly to the ends of the two main girders of the revolving frame by forged steel attachments, and has a length of 125 ft. Normally it is set at an angle to the horizontal of about 25 deg., but it can be set at increased angles up to 40 deg. The suspended pulley may be adjusted to any suitable position of the boom and thus all the advantages of a variable length of boom may be obtained. The lift on the bucket is direct and obtained by the use of the Lobnitz duplex parallel system of hoisting ropes, which has found extensive use in the firm's designs of dipper dredgers. In this method the lower sheave block, close above the bucket in other designs, is eliminated. Only one sheave is used at the point of the boom for the hoisting ropes, and it is mounted as a large floating sheave so that it can turn to suit the side pull of the ropes to any angle. By the introduction of this flexibility the wear of ropes and sheaves due to side pull, is eliminated, and the rope is prevented from coming off the sheave.

Single-geared main hoisting is provided, and the engines installed are of the slow-running, long-stroke type. Usually double-geared, fast-running engines are fitted to this type of plant, but the piston speed has in this case been kept low to ensure easy, silent working and to reduce the wear to a minimum. There are two engines fitted, one for slewing and the second for hoisting, which, however, also serves for the dragging operations and for derricking. The brake bands provided for the control are lined with Ferodo and are of the Lobnitz outside-band type with a spring control. They are pulled into action by means of a compressed-air engine. Steam is generated in two loco-type boilers. The duty is divided between two units to facilitate transport and handling in erection, as well as to facilitate the distribution of the load uniformly over the whole machine. Feed water and fuel can be raised while the excavator is at work. The feed pump is a steam-driven unit, and the coal hoist is operated by the same medium. As the feed is lifted into a tank much of its suspended mud is deposited there. In the design of the complete plant the necessity for using muddy feed water has been well borne in mind, and arrangements have been made to eliminate mud and to make the removal of any matter deposited in the boiler comparatively easy.

The operator's control seat is placed in a position giving a clear view of all operations, whether they be those of digging or dumping, and care has been taken in their design that the working of all the centralised control levers and foot pedals shall entail very little fatigue to the operator. Electric lighting is installed, with head lights fitted in such a position as effectively to illuminate the bucket when working at night, and continuous operation, day and night, is therefore possible. Throughout the machine the parts have been so constructed that easy dismantling is possible, and the distribution of weight is such that the need for any large amount of counterbalancing has been obviated. As dismantling and re-erection may be necessary, all the parts of the structural work are connected together with turned bolts in place of riveting.

Successful trials at the builders' yard at Renfrew have just been completed, and the equipment will now be taken to the site of its future work, where it will be used to cut the irrigation canals in connection with the dam on the Blue Nile at Makwar.

INDUSTRIAL NOTES.

WE give below an abstract of the findings of the Court of Inquiry, set up with regard to the wages in the coal mining industry. We state first the points which had been raised by the Miner's Federation executive, and in each case the Court's conclusions.

(*a*).—That the wages paid to the workers in the collieries under the provisions of the late agreement were substantially less than the equivalent of their pre-war earnings.—With regard to day-wage workers this contention has been established. It is true also with regard to piece-workers in certain collieries, but not in all.

(*b*) That the increase of 2*s*. per shift to adults and 1*s*. to boys under 16, recommended by the Coal Industry Commission in March, 1919, was, at least in part, for the purpose of raising the standard of living of the mine workers.—We cannot tell what was the actual purpose of allowing this increase. Paragraph 5 of the Interim Report by the Chairman suggests that the cost of living was part of the reason. The paragraph in question reads as follows: "We recommend an increase in wage to all colliery workers of 2*s*. and 1*s*. a day respectively, for each day worked. . . . The reason 2*s*. and 1*s*. are recommended instead of a percentage is that it remunerates the lower-paid worker in a fairer degree, and, after all, the necessities of life are no cheaper to him than they are to his more highly-paid comrades."

(*c*).—That the agreement of July 1, 1921, while giving the workmen wages less than the equivalent of pre-war earnings, allowed the owners profits substantially in excess of pre-war profits.—It is true that the agreement permitted this result, and with regard to certain classes of workmen and certain collieries it, in fact, so operated.

(*d*).—That the first charge upon the net proceeds of the industry should be a minimum wage to the workmen. That minimum should include the elements composing the standards as defined in the recent agreement, but revised, having regard to :—(1) The increased cost of living as indicated by the current figures published by the Ministry of Labour; and (2) The improvement in the standard of living provided by the award of the Coal Industry Commission, 1919.—We think that the provision of a minimum wage should have precedence over distribution of profits. We cannot specify conditions as to the basis on which that minimum should be fixed.

(*e*).—That any standard of profits should be at a fixed rate per ton, equal to the pre-war profits per ton. —This is a method for amending the late agreement which has not been discussed before us, and upon which we do not feel competent to express an opinion.

(*f*).—That the earnings of railway wagons and the profits from coking and by-product plants should be regarded as proceeds of the industry.—Where these undertakings are separately owned we do not think their profits can be included, nor apart from agreement does the principle differ where they are under one ownership.

In the course of an interview Mr. W. A. Lee, Secretary of the Mining Association, said that the concrete suggestion made by the Court was that negotiations should be resumed, and that was heartily welcomed by the colliery owners. The owners, he added, felt sure that the miners would agree with them that the report of the findings was a concise and admirable summary of the evidence and dealt fairly with the facts submitted by both sides. He further stated that, in view of Mr. Herbert Smith's undertaking to the Court that he and the Miners' Federation would stand by the Court's findings, the owners had every hope of a satisfactory conclusion resulting from the forthcoming meeting with the miners. A meeting of both sides was held on Tuesday, but nothing of a decisive character was arrived at. The miners repeated the claims they made previous to the setting up of the Court of Inquiry, whilst the owners confirmed that the concessions they had offered were the maximum the industry could afford, adding that since they had offered them the export market had become less favourable. At a meeting on Wednesday the same arguments were reviewed; they were considered afresh at a further meeting yesterday.

We referred in our last issue to the probability of a strike of coal tippers and trimmers occurring in all the coal-exporting ports of the country. The difficulty has in no way arisen on a question of wages, but follows a comparatively small dispute on the engagement of certain charge hands at Leith. A meeting was held last Saturday in that port; the negotiations at the meeting broke down and a national strike was decided upon, to start at 10 p.m. on Wednesday night, the 14th inst. At the time of going to press it is announced that the strike has been postponed, if not averted, by the appointment of a Court of Inquiry.

With reference to the building trades ballot to which we referred in our last issue, Mr. E. J. Brown, director of the London Master Builders' Association, has stated that the figures reveal that only about 25 per cent. of the trade union members took the trouble to vote. He added that no further concession could be made. Since the employers' offer of an advance of one halfpenny per hour the cost of living had fallen five points, and a further reduction was certain following the recent Budget proposals. A conference lasting five hours between representatives of the employers and operatives was held in London last Monday, but no decision was arrived at. The conference was adjourned till Tuesday, when it was agreed that the operatives' negotiating committee should further meet the employers' representatives on Wednesday and Thursday to continue the discussion.

Messrs. Horace Green and Co., Limited, makers of dynamos and motors, Cononley, Keighley, have recently completed their fourteenth financial year and distributed the twelfth annual dividend to their employees. Their profit-sharing scheme is based on the wages paid ranking as capital. Since the introduction of the scheme an average dividend of 8 per cent. has been paid and in the present year it amounts to 7½ per cent. This result is noteworthy considering the difficult trading conditions which had to be contended with during the year.

The sixty-sixth financial report of the Associated Blacksmiths' and Ironworkers' Society for the year down to December 31, 1923, now issued, shows the total income for the year to have been 115,809*l*., whilst the total expenditure, including a sum of 16,726*l*. repaid to the bankers, was 132,015*l*. The membership at the close of the year was 12,459, a reduction of 2,543, but at the time of writing, the report added, there were many indications of a recovery in membership. The report referred to the Boilermakers' strike and lock-out and stated that this led to the suspension of members of other unions, subjecting them to hardships which ought to be avoided. The report hoped that machinery would be introduced soon to regularise procedure and prevent misunderstanding between union and union, and between the unions and the employers.

Speaking last week in Parliament with reference to the question of national expenditure on public assistance, Sir J. Marriott said that no one could deny that this expenditure on various forms of public assistance was immense and almost colossal. The Drage report, which referred mainly to 1922 and applied to England, Scotland and Wales, showed an aggregate amount spent of 371,750,000*l*., of which 277,750,000*l*. was obtained from rates and taxes. From that sum he deducted 89,000,000*l*. included as payment for war pensions and which ought not to be included in any return of public assistance, reducing the latter amount to 188,750,000*l*. There should be added to this sum 23,000,000*l*. spent in recent years by way of charitable assistance, as compared with charitable assistance of about 16,000,000*l*. before the war. Further national expenditure on public assistance had shown a very rapid increase in recent years. Sir J. Marriott also called attention to the overlapping of the different forms of relief and assistance. This was due in part to difficulties of administration, and in part to the ignorance and, to some extent, to the fraud of recipients. He suggested that the House should consider whether it would not be wise to set up a single co-ordinating authority for public assistance. The prime object of public assistance should be not so much directly to help the recipients as to help them to help themselves.

MANCHESTER ASSOCIATION OF ENGINEERS.—The Council have under consideration the syllabus for the next discussion session (1924–1925) and would appreciate offers and suggestions from the members for papers or subjects for topical discussions. It is contemplated reserving an evening for a discussion on the Mechanical and Engineering Sections of the British Empire Exhibition, and offers to contribute short papers thereon will be welcome. It is hoped that the members will respond to this invitation on or before the 31st inst.

200-TON DRAGLINE EXCAVATOR FOR USE IN THE SUDAN.

CONSTRUCTED BY MESSRS. LOBNITZ AND CO., LIMITED, ENGINEERS, RENFREW.

(*For Description, see Page* 636.)

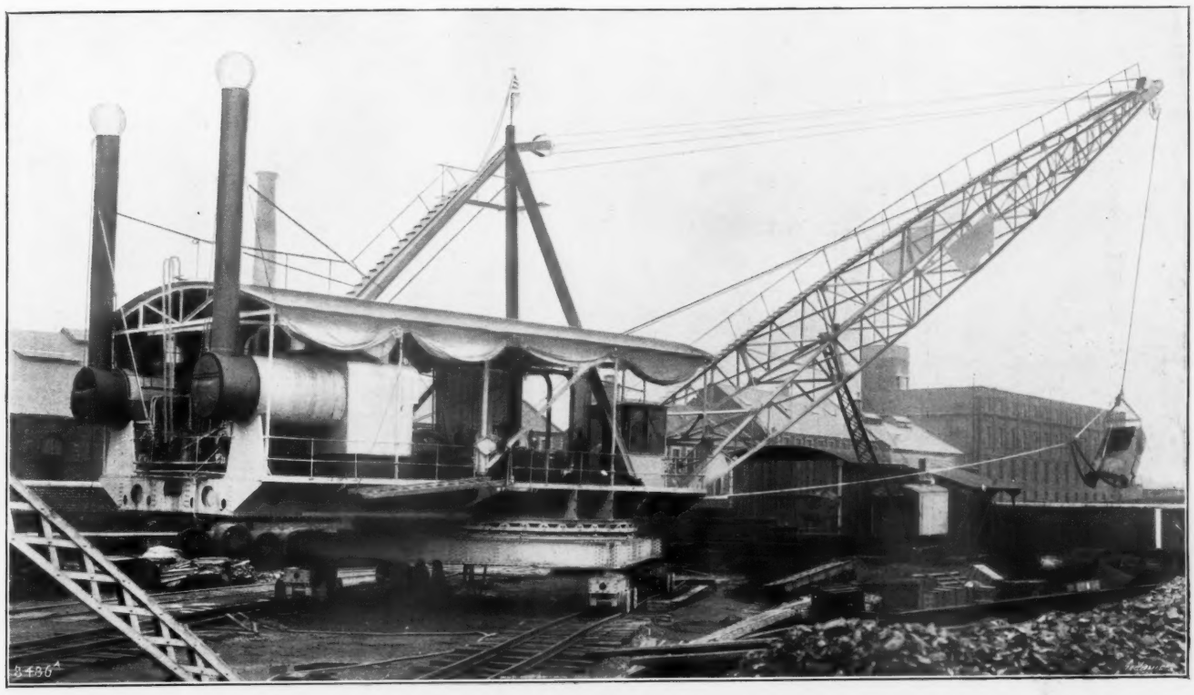


FIG. 1.

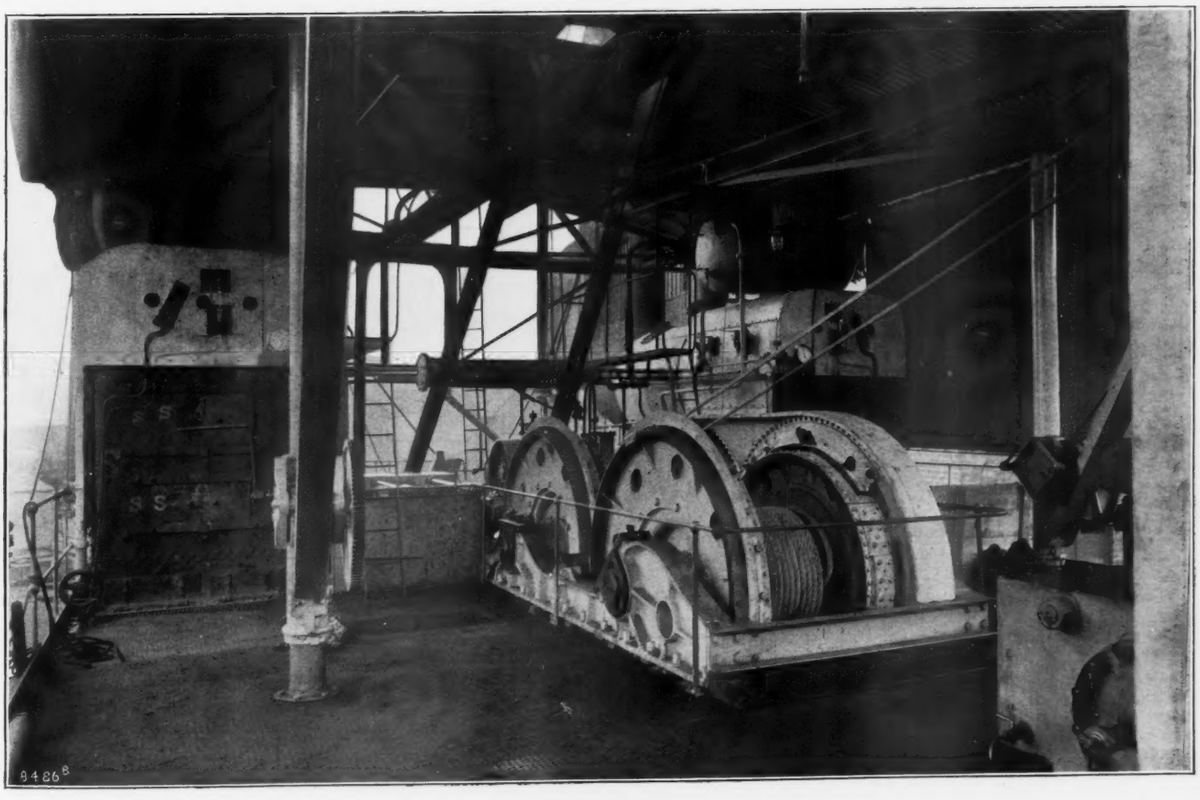


FIG. 2.

(*To face page* 636.)

PALMER'S NEW GRAVING DOCK AT SWANSEA.

MR. N. G. GEDYE, M.INST.C.E., WESTMINSTER, CONSULTING ENGINEER; MESSRS. SIR JOHN JACKSON, LIMITED, CONTRACTORS.

(For Description, see Page 637.)

Fig. 7.

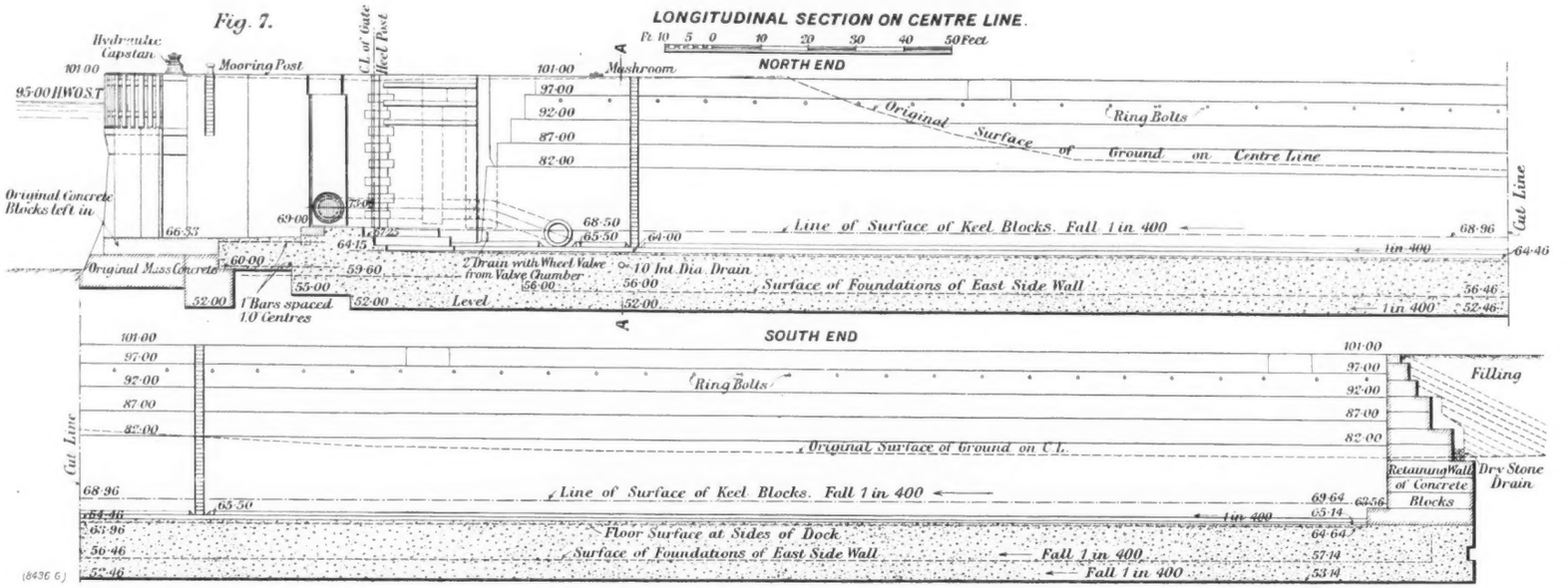

LONGITUDINAL SECTION ON CENTRE LINE.
Ft. 10 5 0 10 20 30 40 50 Feet
NORTH END
SOUTH END
Hydraulic Capstan
Mooring Post
C.L. of Gate Heel Post
Mushroom
Original Surface of Ground on Centre Line
Ring Bolts
Cut Line
95·00 H.W.O.S.T.
Original Concrete Blocks left in
Original Mass Concrete
1" Bars spaced 1.0 Centres
2 Drain with Wheel Valve from Valve Chamber
1.0 Int. Dia. Drain
Level
Line of Surface of Keel Blocks. Fall 1 in 400
Surface of Foundations of East Side Wall
Floor Surface at Sides of Dock
Filling
Retaining Wall of Concrete Blocks
Dry Stone Drain
1 in 400
Fall 1 in 400

Fig. 8.

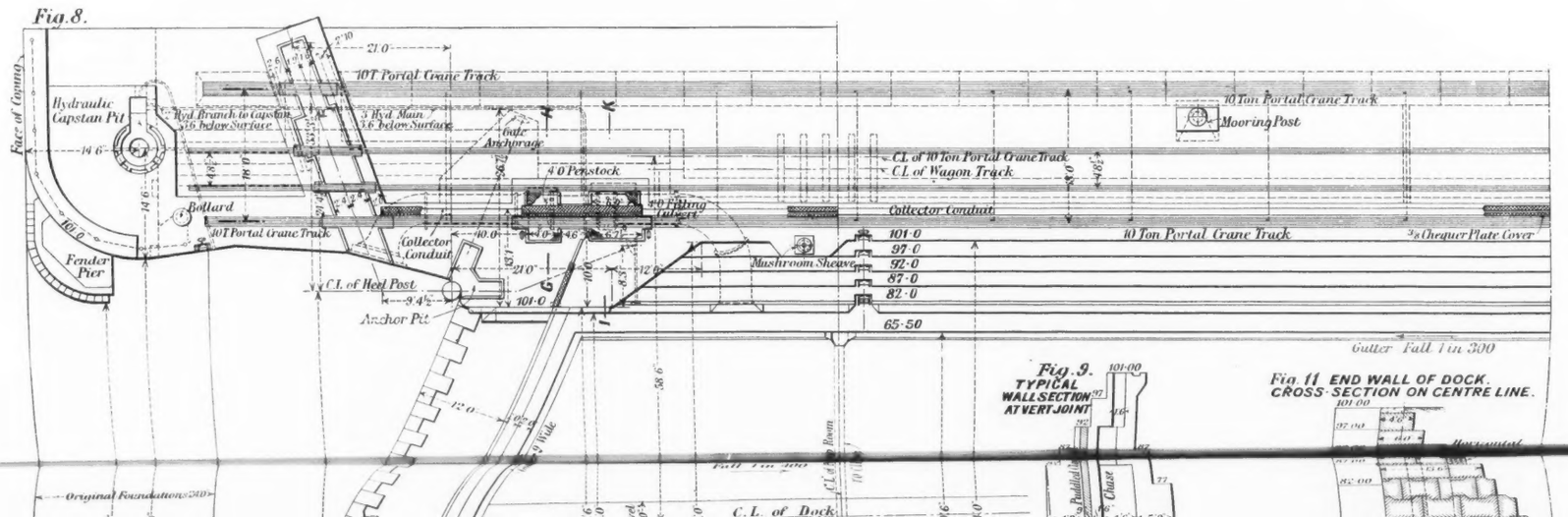


Fig. 9. TYPICAL WALL SECTION AT VERT JOINT

Fig. 11. END WALL OF DOCK. CROSS-SECTION ON CENTRE LINE.

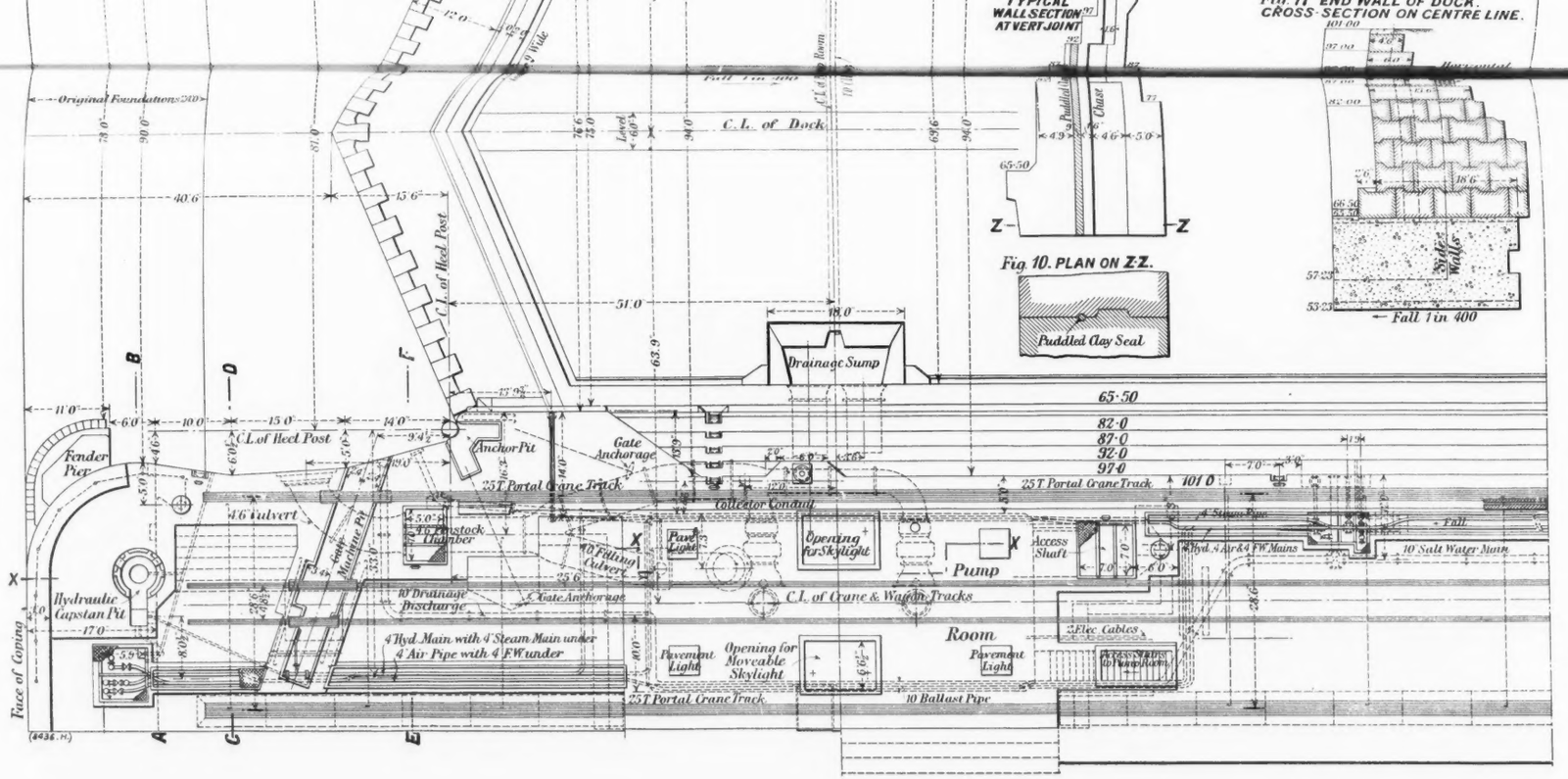


Fig. 10. PLAN ON Z-Z.

TYPICAL WALL SECTION AT VERT. JOINT

TYP. E. END WALL OF DOCK. CROSS-SECTION ON CENTRE LINE.

Fig. 12. CROSS SECTION C.D. (Fig. 8.)

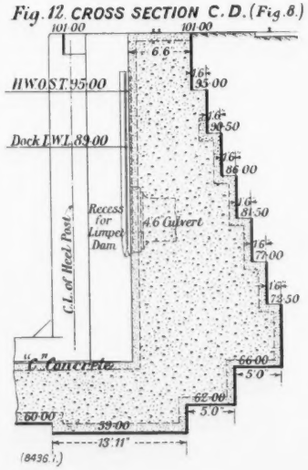


Fig. 13. TYPICAL SECTION OF EAST WALL.

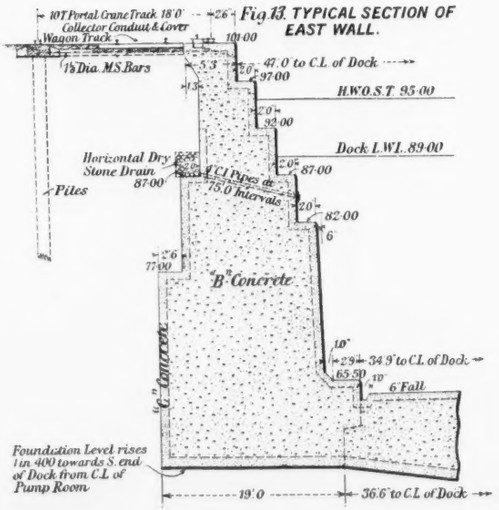
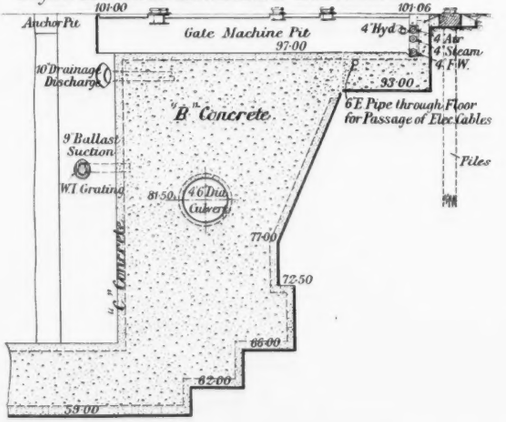

10T Portal Crane Track 18'0
Collector Conduit & Lower Wagon Track
1¼ Dia. M.S. Bars
47·0 to C.L. of Dock
H.W.O.S.T. 95·00
Dock L.W.L. 89·00
Horizontal Dry Stone Drain
4" C.I. Pipes at 15·0 Intervals
Piles
"B" Concrete
"C" Concrete
34·9 to C.L. of Dock
6 Fall
Foundation Level rises 1 in 400 towards S. end of Dock from C.L. of Pump Room
19·0
36·6 to C.L. of Dock

Fig. 14. SECTION ON CENTRE LINE OF GATE MACHINE PIT.



PALMER'S NEW GRAVING DOCK AT SWANSEA.

MR. N. G. GEDYE, M.INST.C.E., WESTMINSTER, CONSULTING ENGINEER; MESSRS. SIR JOHN JACKSON, LIMITED, CONTRACTORS.

(*For Description, see Page* 637.)

FIG. 25. CONDITION OF WORKS IN APRIL, 1923, LOOKING FROM THE SOUTH END OF DOCK.

FIG. 26. CONDITION OF WORKS IN OCTOBER, 1923, LOOKING FROM THE SOUTH END OF DOCK.

(*To face Page* 637.)

PALMER'S NEW GRAVING DOCK AT SWANSEA.

(*Concluded from page* 604.)

HAVING given a general account of Messrs. Palmer's new establishment at Swansea, we may now proceed to a more detailed description of the construction of the dock and of its engineering features. As already mentioned, the new dock has an entrance of 75 ft. in clear width and has been constructed in the first instance with an internal length of 560 ft. Provision is made for lengthening the dock in the future, the inner end wall, which is constructed of concrete blocks, being of a temporary character. The space available for lengthening is indicated in Fig. 2, on page 603, of our last issue. The floor of the dock has a fall from the inner end towards the drainage sump near the front end of 1 in 400 and a cross fall of 6 in. to each side. The drainage gutters at the sides of the dock fall 1 in 300. As already stated, the dock is constructed practically entirely of concrete, granite being used only for the hollow quoins and gate sills. The whole of the granite was obtained from Messrs. Freemans' quarries near Penryn, Cornwall.

When the King's Dock was opened in 1909 it was the intention of the Swansea Harbour Trustees, who were then, and were until 1923, the dock authority, to build a dry dock on the site which is now occupied by Messrs. Palmer's dock. An entrance through the King's Dock wall to which we have already referred, and which is indicated in Fig. 1 (page 602 *ante*), was therefore constructed provisionally, the space between the roundheads being filled temporarily by a wall built of concrete blocks with brickwork and *in situ* concrete superstructure which could, when the dry dock came to be constructed, be removed without serious difficulty. The works comprised in the King's Dock system were constructed upon an area of foreshore which was reclaimed by the construction of a sea embankment. At the site of the dry dock the original foreshore level was about 18 ft. below high-water ordinary spring tides, or 10 ft. above the low-water ordinary spring tides level.

The area lying between the south quay wall of the King's Dock and the sea embankment had not at the time of the completion of the King's Dock works been completely filled with material excavated from the dock bottom, and when the construction of the new dry dock was commenced in 1922 a large portion of the site now occupied by the ship-repairing yard and the dry dock was submerged, the water level standing in the unfilled area at a level of a few feet below high water of ordinary spring tides. An idea of the condition of the site at this stage will be obtained from Fig. 6 on this page.

Messrs. Sir John Jackson, Limited, contractors for the dry dock works, were therefore faced with the necessity of cutting off the site to be occupied by the dry dock from the remainder of the flooded pool before constructional work could be proceeded with. For this purpose a line of steel sheet piling was driven on the east side of the site extending from the King's Dock wall for a distance of 866 ft. southward towards the sea embankment. A timber gantry was first constructed on a line parallel with the steel sheet piling, and this gantry carried the piling cranes and travelling steam cranes, which grabbed material from the area which was to be dried out and deposited the excavation on either side of the steel sheet piling to serve as backing, as shown in Fig. 6. The piling was driven, on the average, to a depth of about 6 ft. into the original foreshore, which consists of sand and gravel with small boulders. A certain amount of clay and loam was found mixed with the gravel in some parts of the work.

After the construction of the sheet piling dam had been completed, and the enclosed area pumped out, the excavation for the walls of the dock was proceeded with both on the east and west sides, timber staging being constructed for the purpose of carrying travelling derricks, wagon roads and concrete mixers. Excavation generally was carried out in the open down to the level of the original foreshore. Below that level the excavation for the side walls was in timbered trenches. The concreting of the side walls of the dock was carried out in sections of about 60 ft. length, a vertical V-joint being formed at the junction of adjoining sections. After portions of the side walls on both sides of the dock had been brought up about half-way the remaining portions of the dumpling between the side walls were excavated down to a level of about 3 ft. above the finished floor level. The excavation for the floor, sill and apron was then proceeded with in alternate sections, each 20 ft. long, excavation being carried down in timbered cross trenches extending across the dock from wall to wall. The excavation and concreting of the intermediate sections was effected after the concrete had been deposited in the adjoining sections.

A longitudinal section of the dock is given in Fig. 7 on Plate LXIII, and a detailed plan of the entrance end in Fig. 8 on the same plate. Details of the walls are given in Figs. 9 to 14. The V-joint between two of the 60-ft. sections is illustrated in Figs. 9 and 10. As will be seen, a 9-in. diameter puddled clay seal is arranged on the joint to prevent leakage into the dock from the standing water in the ground surrounding the dock The temporary end wall of the dock is shown in Fig. 11. The interlocking concrete blocks, of which the lower part of the wall is constructed, were available on the site, some of them being removed from the original wall which was removed to make the entrance to the new dock, and some being spares which were purchased from Messrs. Topham, Jones and Railton, the King's Dock contractors.

Before the concrete block wall at the entrance to the dry dock could be removed a cofferdam enclosing the future entrance had to be constructed in the King's Dock. This cofferdam consisted of steel-sheet piling driven into the dock bottom and supported by timber strutting from the King's Dock wall and the temporary concrete block wall. When the latter was removed the struts which were supported by it were taken out and long diagonal struts substituted, the latter butting on the concrete fender piers, which had in the meantime been constructed in the entrance. These fender piers can be seen in Fig. 8. It should perhaps be pointed out that the round heads at the entrance to the dock were built at the time the King's Dock was constructed and were connected by the temporary concrete block wall, to which reference has already been made. The entrance formed by these roundheads was somewhat wider than was necessary for the dock which has been constructed, and the arrangement allowed of the building of the timber-faced fender piers, which give an easy entrance to the dock and at the same time form chambers for the gates when in the open position.

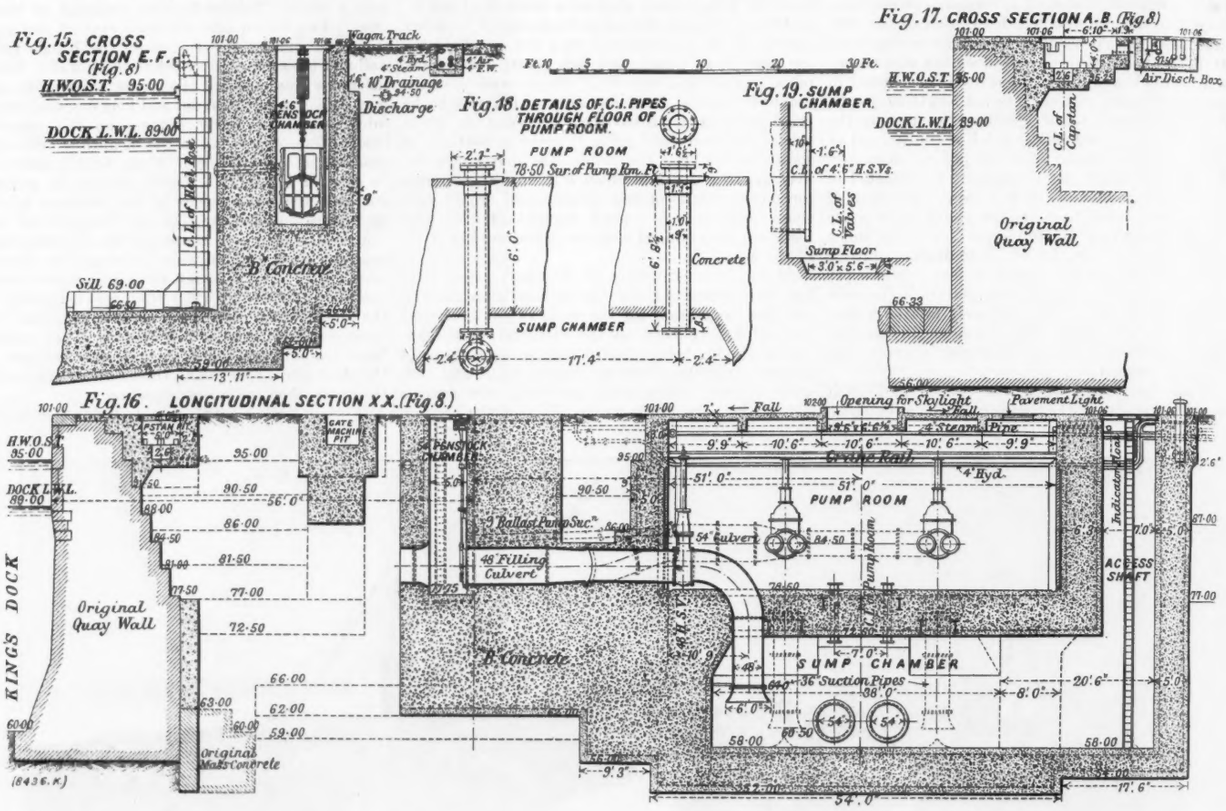
Work on the site of the dry dock was commenced by the contractors on April 21, 1922. The steel sheet piling dam on the east side of the site was completed in August, 1922, and the King's Dock cofferdam in December, 1922. The construction of the concrete walls was commenced at the end of December, 1922, and the whole of the concrete work in the body of the dock was completed early in February, 1924. The entrance gates were completed and the removal of the King's Dock cofferdam was commenced on April 4, 1924. Fig. 6 on this page, together with Figs. 25 and 26 on Plate LXIV, give good ideas of the work at different stages. During the construction of the works pumping on the site of the dock had to be carried on continuously. The standing water level in the ground surrounding the site is about 5 ft. below H.W.O.S.T., and the underside of the floor is placed at a level of 43 ft. below H.W.O.S.T. It was found necessary to employ three 12-in. centrifugal pumps in addition to a few smaller pumps for de-watering the site. During the greater part of the time two 12-in. centrifugal pumps were found sufficient to deal with the inflowing water.

The de-watering pump chamber is placed on the west side of the dry dock, and the west wall of the chamber will form a portion of the side wall of the No. 2 dock when this is constructed. It is shown in Figs. 15 to 23, on the opposite page. The pump chamber is situated completely below the coping level of the dock. Underneath the pump room is a sump chamber communicating with the dock by means of two 54-in. diameter cast-iron culverts.

FIG. 6. CONDITION OF WORKS IN OCTOBER, 1922, LOOKING FROM THE SOUTH END OF DOCK.

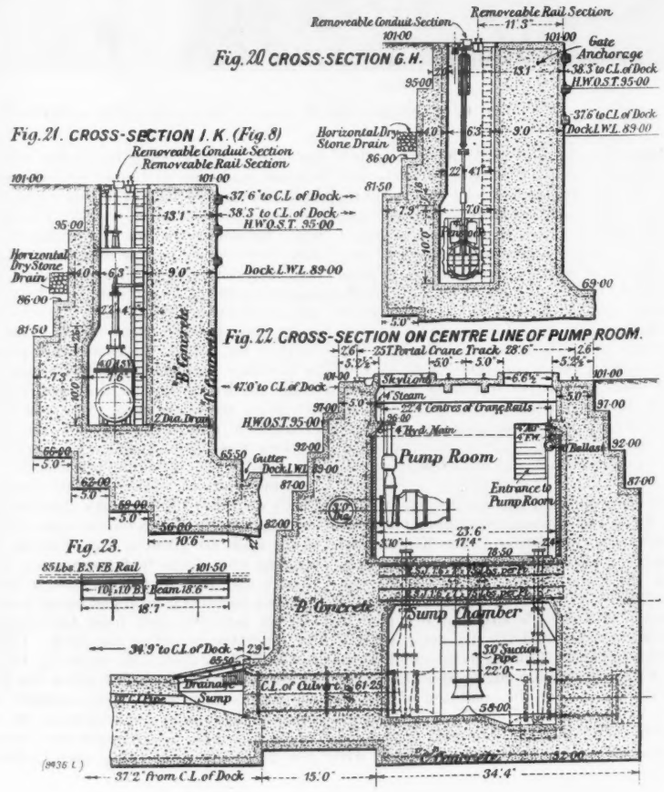
PALMER'S NEW GRAVING DOCK AT SWANSEA.

MR. N. G. GEDYE, M.INST.C.E., WESTMINSTER, CONSULTING ENGINEER; MESSRS. SIR JOHN JACKSON, LIMITED, CONTRACTORS.



When the second dock is constructed, the inner ends of these culvert pipes will be fitted with hydraulic sluice valves operated from the pump room, and similar valves will be placed on the inner ends of the culvert pipes communicating with the No. 2 dock. The pumping plant will thus be available for de-watering the second dock when the latter is constructed. The pumping installation consists of two 36-in. diameter centrifugal pumps of twin impeller pattern discharging into a cast-iron delivery culvert 54-in. diameter. The sluice valves on the pump discharges as well as those on the filling culverts are operated hydraulically. "Standby" hand-operated penstocks are also fitted in all the culverts. Each of the main pumps is driven by a 280-b.h.p. electric motor. The auxiliary pumps installed in the pump room include a 10-in. diameter centrifugal drainage pump, 9-in. centrifugal ballast pump, vacuum charging pump, and a 2-in. diameter centrifugal pump for draining the pump room, all of which are electrically driven. The total water content of the dock at high water ordinary spring tide level without a ship in dock is 1,364,000 cub. ft. This quantity of water can be pumped out of the dock in 2 hours 30 minutes.

The contractors for the pumping installation were Messrs. Gwynnes Engineering Company, Limited, of Hammersmith, the electric motors and switchgear being supplied by Messrs. Metropolitan-Vickers, Limited. The main pumps are of the "Invincible" twin parallel type, having two 22-in. discharge branches, each pair joined by a 36-in. breeches pipe, and a common suction branch. The casings are divided horizontally and vertically so that the top halves can be taken off to lift out the impellers on the shaft without breaking pipe joints. The top halves have inspection hand holes of ample size in convenient positions. The impellers are of the double-inlet type, eliminating end thrust, with shrouded vanes of the Francis turbine design. The shafts are mild steel forgings, supported inside



the pump by renewable split bushes of hard bronze behind the stuffing boxes with efficient lubrication. The bearings have large oil wells, inspection openings, level gauge, double oil rings and draw-off cock. These pumps have couplings of the pin flexible type to connect the motors, with renewable insulation washers of leather.

The two main pumps run at a constant speed of approximately 490 r.p.m., and the power required by each unit averages about 269 brake horse-power at the pump coupling during the de-watering operation. The maximum efficiency is 83 per cent. The estimated static head at which the maximum efficiency of the main units will be obtained is 25 ft.

The sump pump is a 2-in. "S" type "Invincible" low-lift centrifugal pump, arranged with extended bed and complete pin coupling for motor drive, while the drainage pump is a 10-in. "Invincible" low-lift centrifugal arranged with extended bed and complete pin flexible coupling for the motor drive. The stuffing boxes have renewable gun-metal bushes with grease lubrication, and brass lantern rings with water seals. The casing is provided with a side cover so that dismantling can be effected without breaking pipe joints. The pump is complete with standard requisite fittings, including air relief and drain cocks, priming water level gauges, provision for exhauster connection and suction and delivery gauges. The ballast pump is a 9-in. L.L. "Invincible" pump, provided with 9–10-in. taper piece for forming a 10-in. delivery. There is one vertical 2-throw single-acting "Invincible" exhauster with cylinders 6 in. by 4 in., arranged for motor drive with single machine-cut reduction gear, consisting of cast-iron spur wheel and pinion of raw hide. Wrought-iron charging piping for connecting the pump to the main units and drainage pump is provided, and stop valves between the exhauster and the top of the main pump casing, together with ball float check valves and gun-metal cocks, so that the pumps can be charged together or separately.

The drainage pump, which is driven by a 37-brake horse-power motor, will deliver 1,800 gallons of sea water per minute, against a total head from all causes of 42 ft. when running at 720 r.p.m. and absorbing 32·75 brake horse-power on the pump spindle. The ballast pump is capable of discharging 1,400 gallons per minute against a total head from all causes of 60 ft. when running at 960 r.p.m. and absorbing 36·65 h.p. on the pump spindle. It is driven by a 42-h.p. motor. The pump-room drainage set is capable of discharging 60 gallons per minute against a total head of 30 ft. when running at approximately 1,440 r.p.m. and absorbing 1·9 h.p. on the spindle. The exhauster is of the double-throw type driven through gearing running at approximately 300 r.p.m., and is capable of priming each unit in approximately seven minutes. The current supply to all motors is three-phase, 50 cycles, 440 volts. The hydraulic and other valves in the pump room were supplied by Messrs. J. Blakeborough and Sons, of Brighouse, Yorks. An interior view of this pump room is given in Fig. 24 on this page.

The dock gates are of steel and are opened and closed by means of hydraulic gate machines. The gates are of the semi-buoyant type, watertight air chambers being constructed in the lower part of each leaf. The upper part of each leaf consists of a water-ballast chamber, into and out of which the water is free to flow as the level of the water inside the dock rises or is lowered. The castings for heel pivots, bottom sockets, and top pivots are of steel. No rollers are fitted, and the total unbalanced weight of each leaf is approximately 18 tons. The gate anchorages are, however, designed of sufficient strength to carry the gate when swung in the dry or with the whole of the air compartments filled with water. The total weight of steelwork in each leaf of the gates is approximately 86 tons. The swinging weight of each leaf, including timber fendering, gangway, &c., is 100 tons. The hydraulic gate machines have cylinders 10 in. diameter.

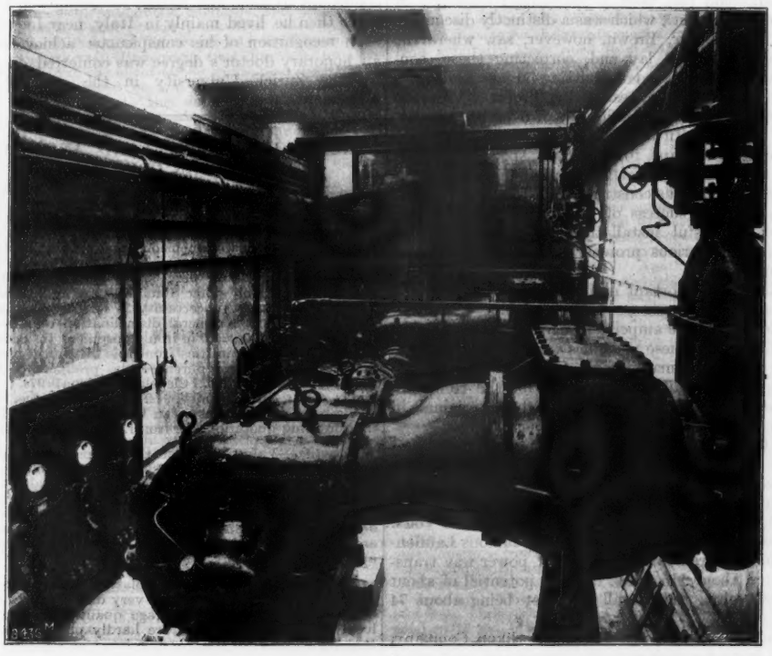


FIG. 24. INTERIOR OF PUMP CHAMBER.

Two 5-ton hydraulic capstans are fixed, one on each side of the dock entrance, and a 7-ton hydraulic capstan at the inner end of the dock. The hydraulic power for operating the gate machinery and capstans is taken from the Great Western Railway Company's power mains at a pressure of 750 lb. per square inch. The contractors for the gates and hydraulic machinery, including the capstans, were Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited.

The keel blocks are of cast iron with oak capping blocks and soft wood liners. The cast-iron blocks are made in three sections tapered and machined on meeting faces. The blocks are set on pitchpine bearers laid longitudinally under the blocks which are spaced 3 ft. 3 in. apart centre to centre. The total height of the blocks from the concrete floor to the top of the soft wood packing is 4 ft. 6 in. Mild steel cotter pins are provided for keying up the block sections. The keel blocks are designed for a loading of 36 tons per lineal foot measured along the centre line of the dock. The blocks are mounted on the longitudinal timber bearers in groups of four, the bearers being discontinuous, so that if repairs to a keel plate of a ship are necessary a complete section of blocks can be unwedged and withdrawn without any cutting away being necessary.

The equipment of the dry dock includes a 25-ton electric travelling portal crane and a similar crane of 10-ton capacity, one on each side of the dock. One rail track for the 25-ton crane is laid on the west wall of the dock, the other track being carried on a temporary piled foundation, but this will eventually be laid upon the side wall of the No. 2 dock when it is constructed. The 10-ton crane on the east side of the dock likewise has one track laid on the dock wall, while the other track rests on a track beam supported by timber piles. The 25-ton crane is designed to lift the full load at 73 ft. radius, 15 tons at 100 ft. radius, 10 tons at 112 ft. radius and 4 tons on the auxiliary hook at 119 ft. radius. The crane carriage is of the portal type, having a span of 28 ft. 6 in. and a clear height of 17 ft. under the portal. The total weight of the crane in working order is approximately 220 tons. The level luffing gear is of the "Toplis" type. The crane travels on 16 wheels provided with central flanges to suit twin rails. These wheels are carried in compound bogies, four at each corner of the crane, two wheels at each corner being geared for travelling. The current supply is 3 phase, 50 cycles, 440 volts, and is collected from bare trolley wires carried in a conduit adjacent to the rails on the dock side of the track. The crane has been subjected to a test load of 31¼ tons in all motions and a static test load of 50 tons. The 10-ton crane is of similar construction and lifts the full load at 59 ft. radius and 4 tons at 70 ft. radius. Both these cranes, together with a 20-ton overhead electric travelling crane in the large fitting shop, were constructed by Messrs. Stothert and Pitt, Ltd., of Bath. Railway tracks are laid on each side of the dock between the crane tracks.

The arrangements provided for supplies of water, compressed air, steam, &c., are very complete. A pipe trench is constructed behind the west wall of the dock, in which are laid pipes for supplying air, steam and fresh water to the dock side. This pipe trench also contains the hydraulic supply mains. A 10-in. diameter salt water ballast pipe is laid alongside the pipe trench; water is pumped direct from the wet dock into this pipe and delivered under a head of 60 ft. The ballast pipe can also be used for conveying oily water from the dock bottom, a branch connection with the drainage pump being provided for this purpose, and for the discharge of oily water direct from ships' tanks by means of branch connections on the dock side. Near the inner end of the dock a "Rocket" oil separator apparatus has been installed. This separator is capable of dealing with 50 tons of oily water per hour and is connected by means of a branch pipe with the ballast main. The fresh water and steam pipes as well as the hydraulic mains are 4 in. diameter and the compressed air main 6 in. On the air mains, in addition to flanges for the connection of large branch pipes, a distribution box with unions for flexible pneumatic hose is provided on the face of the dock wall abreast each valve pit. A branch air main, provided with distribution boxes, is also fixed to the side wall of the dock on its west side near the floor of the dock. Valve pits are constructed at intervals along the dock side with connections carried through the dock wall for attachment to pipes carrying supplies of steam and fresh and salt water to the dock bottom or on board ship lying in dock. Electric cables are laid alongside the dock walls, and connections to plug boxes, which are recessed under the wall coping, are provided at frequent intervals. The pipe and cable arrangements are indicated in Fig. 8, on Plate LXIII.

The equipment of the ship-repairing and engineering yard includes a series of steel framed buildings consisting of platers', fitters', plumbers' and blacksmiths' shops, foundry, joiners' and carpenters' shop, paint shop, stores and compressor house, in addition to office and other buildings. The platers

shed measures 230 ft. in length by 75 ft. in width, and is 27½ ft. in height to the eaves. The fitting hop is 160 ft. by 45 ft. and 30 ft. in height. A 20-ton electric travelling crane travels the whole length of the fitting shop and provision has been made in the platers' shed for a 5-ton overhead electric travelling crane. The shops are fitted up with complete mechanical plant for ship repair and engineering work. The contractors for the steel buildings were the Glasgow Steel Roofing Company, Limited, of Glasgow. The general offices, which are of brick with stone dressings, are situated near the south-west corner of the yard. Adjoining them is a transformer station in which the main electric supply at 12,000 volts alternating is transformed down to 440 volts. The general lay-out of the yard is indicated in the plan, Fig. 2 (page 603, *ante*).

In addition to a berth 380 ft. in length in the King's Dock at the entrance to the dry dock, which is available for fitting-out purposes, Messrs. Palmers Company have acquired a fitting-out berth, 1,200 ft. in length, in the adjoining Queen's Dock, where a lay-by jetty for repairing purposes is to be constructed. This berth is of ample dimensions and depth to accommodate the largest ship which can enter the dock. The King's Dock, from which the dry dock will be entered, is the largest and most up to date of the Swansea docks, and has, with the Queen's Dock and the subsidiary docks in connection with it, a water area of about 250 acres. The King's Dock entrance lock is 870 ft. in length and 90 ft. in breadth, with a depth over the inner sill of 33 ft. at H.W.O.S.T. The new dry dock at Swansea has a clear width of entrance considerably greater than that of any dry dock in the South Wales and Monmouthshire ports.

As we have already stated, Mr. N. G. Gedye, M.Inst.C.E., of Westminster, was the consulting engineer to Messrs. Palmers Company for the whole of the works, and Messrs. Sir John Jackson, Limited, acted as main contractors. We are much indebted to Mr. Gedye for information and drawings relating to the dock and to Mr. W. H. S. Tripp, M.Inst.C.E., the resident engineer, for conducting us over the works. The dock was officially opened on Wednesday last by Lady Pole, wife of Sir Felix Pole, General Manager of the Great Western Railway.

THE LATE MR. C. E. L. BROWN.

IT has been said that modern methods of electric power generation and distribution are pre-eminently due to three men, viz., Mr. S. Z. de Ferranti, Sir Charles Parsons, and Mr. C. E. L. Brown. It was Mr. Ferranti who was the first to realise that the path of progress lay in the development of large power stations feeding sub-stations through long transmission lines, and he did much to solve the problem of constructing these lines by his invention of the lead-covered paper insulated cables. By his development of the steam turbine, Sir Charles Parsons practically halved capital and running costs of steam-operated power stations, whilst to Mr. C. E. L. Brown is mainly due the practical development of three-phase transmission. It is with great regret that we learn that Mr. Brown died at his home at Montagnola, Italy, on May 2 last, after a short illness. Born in 1863, he was the eldest son of the Charles Brown who, when a young man, was induced by Messrs. Sulzer, of Winterthur, to make his home in Switzerland, where the work he accomplished was of such importance that he has been acclaimed as the father of Swiss mechanical engineering.

Mr. C. E. L. Brown inherited to the full his father's ability as a designer, and long before his remarkable work on three-phase transmission had made his name generally familiar, he had acquired a high reputation as a highly original but also exceptionally sound designer of continuous current machinery.

He was educated by his father along lines more characteristic of English than of Continental systems of training engineers. His theoretical knowledge was picked up at local schools and in practice, and he was in no way a mathematical expert. As previously proved by Faraday, however, facility in handling formulas is not essential to accurate and highly original thought. To the man of ordinary capacity no doubt mathematical methods of approaching new problems are generally the simplest, but possibly this is in part due to the circumstance that mathematics often makes it possible to dispense with thought. Formulas are manipulated according to certain definite rules, and the required result is obtained without the necessity of visualising the physical character of the phenomena dealt with. Lacking this mathematical crutch, however, algebra has to be replaced by hard thinking, and given some touch of genius there is perhaps some accruing advantage for such pioneering work as Mr. Brown accomplished, of the engineer being compelled to consider problems of design wholly in their physical and mechanical aspect.

So much did Mr. Brown's ability impress those associated with him that, when scarcely 23 years old, he was appointed director of the electrical department of the Oerlikon engineering works, and whilst holding this post he gave the first demonstration of the commercial practicability of electric power transmission. This work was described in our issue of March 11, 1887. Up to that date, about the best result obtained in electric power transmission had been a commercial efficiency of some 45 per cent., which was a distinctly discouraging result. Mr. Brown, however, saw where the defects of design lay and, correcting these, constructed a plant for transmitting 50 h.p. a distance of five miles. As tested by Professor Amsler-Laffon, a commercial efficiency of over 70 per cent. was realised. In addition to noting the high efficiency of the plant, for that date, special attention was also drawn by Prof. Amsler-Laffon to the simple solid and judicious construction of the dynamos and motors. The success of this pioneer plant led to other successful installations, and in connection with these various protective devices had also to be originated.

His next important new work was the design of low-tension generators for aluminium reduction, current of 12,000 amperes being required at from 12 to 15 volts. These machines were finished in 1888, and embodied many novel features. In 1892 he designed the railway generators for the Heilmann locomotives, which again were both original in design and satisfactory in operation.

Alternate current work was taken up in 1889, at first with single-phase systems and later on with the three phase. The adoption of oil insulation for transformers was originated by him in 1890, and with this he made experiments up to 40,000 volts. These led him to adventure on the famous Lauffen-Frankfort transmission in which power was transmitted about 115 miles, under a potential of about 8,000 volts., the overall efficiency being about 74 per cent.

In 1891 Mr. Brown left the Oerlikon Company, and in conjunction with Mr. Boveri and his brother Sidney Brown, founded the since famous works at Baden. These were originally laid out to accommodate 40 men as a maximum, and during the first year of operation only 16 were actually employed. Castings were purchased and most of the machine work done by outside firms, the designing and the winding alone being undertaken by the new firm. The firm prospered from the outset and scored a great triumph in 1894 by securing the contract for the equipment of the Frankfort Municipal Power Station. German electricians were then still devoted to continuous current machinery, and knew very little about alternating current plant. They strongly opposed the innovation, but the city council nevertheless accepted the advice of their great engineer, Mr. W. H. Lindley, and awarded the contract to the Swiss firm. Needless to say it was a striking success.

A few years later Mr. Charles Brown, the elder, became convinced of the importance of the Parsons steam turbine, and endeavoured to persuade his old firm, Messrs. Sulzer Brothers, to take up the Continental rights. They, however, were absolutely convinced that no steam turbine could approach in efficiency the Sulzer engine, which had an international reputation for excellence. At that time the advantage the turbine had in utilising "the toe of the diagram" was not realised by engineers, and moreover, but small units had been built, and as is well known the steam turbine makes its best showing in large sizes.

Failing with his old firm, Mr. Charles Brown in 1900 persuaded his sons and their partner to make the venture. His task was rendered easier by the fact that his son had visited the Manchester Square station in 1895, and been much impressed by the possibilities of the new type of prime mover. Success followed at once, and the turbine proved even better than its promise. Mr. C. E. L. Brown was, however, dissatisfied with the type of generator originally used, and with his accustomed mechanical insight devised the high-speed rotary field machine, which has been copied the world over.

The subject of our memoir had the artistic temperament, and worked best in fits and starts. During his earlier years, of course, this constitutional peculiarity could not be indulged, but when the new firm was well established he used to take long absences, and on his return from these would do work no one else could attempt, as his partners were the first to recognise. As time went on, however, the growth of the firm forced more and more administrative and financial burdens on to Mr. Brown, whose tastes and special abilities lay much more on the technical side. He began therefore to find the conditions irksome and retired accordingly in 1911. Since then he lived mainly in Italy, near Lugnano.

In recognition of his conspicuous achievements an honorary doctor's degree was conferred on him by the Zurich University in the year of his retirement.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Though there is little business passing just now in Cleveland pig-iron, the position in this branch is quite healthy. Stocks have been reduced to small dimensions, and running contracts are such as to necessitate continued withdrawals from makers' stores. Small parcels are still being sold to the Continent, and home foundries are taking rather larger supplies, but uncertainty is felt as regards the future, and there is general disinclination to negotiate on forward account. Pig-iron consumers in Scotland are drawing fair quantities from this district at cheaper prices than they can purchase the products of areas beyond the Tweed. No. 1 Cleveland pig iron is 97*s.*; No. 3 g.m.b., 92*s.*; No. 4 foundry, 91*s.*; and No. 4 forge, 90*s.*—all f.o.b. Tees. Purchases can be made at rather below the foregoing quotations for iron f.o.t. makers' works.

Hematite.—Values of East Coast hematite iron are inclined to stiffen. Makers' stocks are dwindling, and demand promises to improve. A few more sales to the Continent are reported, and local users are taking rather larger supplies, whilst parcels have been disposed of for despatch to the Sheffield district. Nos. 1, 2, and 3 are fully 99*s.*; and No. 1 hematite is quoted a shilling above mixed numbers.

Blast-furnace Coke.—Durham blast-furnace coke quotations are irregular. Sellers are very disinclined to name below 28*s.* 6*d.* for good average qualities delivered to local consumers, but users are hardly prepared to pay that figure, and they report purchases at a little less.

Foreign Ore.—There is next to nothing passing in foreign ore. Nominally market rates are based on best rubio at 23*s.* 6*d.* c.i.f. Tees.

Manufactured Iron and Steel.—Sales of manufactured iron and steel are not very easily arranged, but there is rather more inquiry for one or two descriptions of material. Common iron bars are 12*l.* 10*s.*; iron rivets, 14*l.* 10*s.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge, and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; heavy steel rails, 9*l.*; fish plates, 13*l.*; black sheets, 13*l.*; and galvanised corrugated sheets, 17*l.* to 17*l.* 10*s.*

THE LATE MAJOR S. UTTING.—We regret to have to announce the death, which occurred on the 4th inst., of Major S. Utting, of Grosvenor Mansions, 82, Victoria-street, S.W.1, who was well known in the engineering world as a specialist in fuel economy. After several years in general engineering practice Major Utting definitely associated himself with fuel economy questions, and in 1912 he started business on his own account at the above address, since which date he had been the British representative for the Louis Prat system of induced draught and had been responsible for the installation of this type of plant in many central stations and industrial works throughout the country. In this connection, the new Prince's station at Nechells, Birmingham, can be mentioned, where extensions are being carried out at the present time. During the war, from 1914 to 1919, Major Utting served with the British Forces in France and Flanders, and was commanding officer of various units of the Mechanical Transport Section. After the war he devoted attention also to the pre-heating of air for boilers and for industrial purposes. He was a member of the Institution of Mechanical Engineers and associate member of the Institution of Electrical Engineers.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Mixed conditions, with a set-back in some sections more or less counterbalanced by a further improvement in others, continue to mark the steel and engineering trades of this district. Taking no cognisance of the political aspect of the position arising from the McKenna Duties, the fact is to be recorded that on instructions received from Birmingham, Coventry, and other automobile engineering centres, deliveries of motor-car cranks, axles and other constructional parts and fittings from Sheffield have been curtailed twenty-five per cent. The growth of business in motor supplies was one of the principal factors in assisting the engineering trades to weather the worst effects of the recent period of depression. Several large firms have quadrupled their output on this account, and found employment for greatly augmented staffs. The demand for crude steel is maintained at a high level, and is supported by a falling off in Continental competition, though the trouble which has arisen at three of the largest producing establishments in connection with the demand from several trade unions for the institution of district rates and conditions, has not yet reached a satisfactory solution, and gives anxiety as regard future working. Increased tonnages of acid steel are going into commission in departments supplying railway locomotive and wagon builders, though owing to the big extensions made within recent years to engineering works of the latter description, rapid inroad is being made into the orders recently booked. Apart from the requirements of automobile engineers, the demand for special steels is much below production capacity, being hindered by exchange differences and tariff barriers in foreign markets. High-speed steel has not properly recovered from the effect of the widespread distribution of stocks purchased on war account. Quotations for steel alloys, owing to this depression, have slumped, supplies being available at about one quarter the price reached during the war. Tool manufacture represents by far the brightest section of local industry. Requirements of milling cutters, taps, and dies appear to be in the ascendant. Orders for files seem to be very unevenly distributed, but the majority of works engaged on these products are now running at about seventy per cent. capacity. There is also a livelier demand for engineers' tools, saws, spades, shovels, forks, pliers and pincers.

South Yorkshire Coal Trade.—The contraction in the demand generally experienced during the past three or four weeks has had the inevitable effect of forcing prices to a lower level. The only exceptions are slacks and smalls, for which there is a steady call on home industrial account. House coal, in which arrears have been wiped off, has been reduced on an average two shillings per ton. Steam hards, which have suffered from the fall in the export demand, has been marked down by 2*s.* 3*d.* to 2*s.* 6*d.* per ton, while best quality nuts are one shilling to two shillings easier. Coke, on the other hand, is a steady market at maximum rates. Quotations:—Best branch handpicked, 34*s.* to 37*s.*; Barnsley best Silkstone, 31*s.* 6*d.* to 33*s.* 6*d.*; Derbyshire best brights, 29*s.* 6*d.* to 32*s.* 6*d.*; Derbyshire best house, 26*s.* to 28*s.*; Derbyshire best large nuts, 25*s.* to 26*s.*; Derbyshire best small nuts, 19*s.* 6*d.* to 22*s.*; Yorkshire hards, 25*s.* to 27*s.* 6*d.*; Derbyshire hards, 23*s.* to 25*s.*; Rough slacks, 12*s.* 6*d.* to 15*s.* 6*d*; Nutty slacks, 12*s.* to 14*s.* Smalls, 8*s.* to 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There has been very little change in the Scottish steel trade during the past week and buyers continue to show little inclination to enter the market. The demand on the whole is not heavy, and it is quite wonderful how some of the establishments are managing to carry on. Inquiries are a shade better, and although some are always resulting in business the actual tonnage is not heavy. The outlet for plates is very limited in the meantime, but sectional material is moving rather more freely. In the black sheet trade only a moderate amount of business is passing, and although the home trade is not accounting for much of it there is certainly a slight improvement in that direction. Prices are nominally unchanged and to-day's quotations are as under:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, $\frac{7}{8}$ to $\frac{1}{4}$ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations. An industrial dispute has taken place this week at one of the local steel works over the proposed introduction of the contracting system on the plate mill loading bank. About 1,500 men are affected.

Malleable Iron Trade.—The position in the malleable iron trade of the West of Scotland has not improved very much lately but a few fresh lines have been picked up this week. In most cases, however, the tonnage is small but everything is very acceptable in these days of dull trade. Specifications against contract are slow and makers cannot see any distance ahead. In the steel re-rolling branches there is a shade more business being booked. The price of "Crown" bars keeps steady at 12*l.* 10*s.* per ton, delivered Glasgow stations.

Scottish Pig-iron Trade.—Business in the Scottish pig-iron trade is inclined to be quiet but a fairly good undertone is noticeable. Buyers are acting with caution and are not covering forward to any extent. Inquiries on the whole are fairly satisfactory but fresh lots are rather difficult to fix up. Hematite is slow of sale owing to the quietness in the steel works. Prices are keeping firm and are quoted as follow:—Hematite, 5*l.* 2*s.* 6*d.* per ton, delivered at the steelworks; foundry iron, No. 1, 5*l.* 5*s.* per ton, and No. 3, 5*l.* per ton both on trucks at makers' yards.

Scottish Pig-iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, May 10, amounted to 1,473 tons. Of that total 1,325 tons went overseas and 148 tons coastwise. For the corresponding week of last year the figures were 877 tons 10 cwt. foreign and only 51 tons coastwise, making a total shipment of 928 tons 10 cwt.

Shipbuilding.—An order has lately been received for a screw tug between 80 and 90 ft. in length by Messrs. John Cran and Somerville (Limited), Leith. This tug is for the Thames Union Towage and Lighterage Company and is for early delivery.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The threatened national stoppage of coal trimmers and tippers which was to have taken effect to-night brought new business on the market to an almost complete standstill, as merchants were reluctant to enter into commitments in view of the possibility that shipment work would be suspended. Happily the stoppage was called off this afternoon, the Minister of Labour having been successful in his efforts to avert a strike by the setting up a Court of Inquiry to go into the question of the Leith dispute in connection with which a sympathetic strike is threatened. Generally prices were maintained despite the paucity of new business, and for spot delivery small lots secured higher levels, as owners in many cases were anxious to get their boats away as quickly as possible. Best admiralty large ruled from 28*s.* to 28*s.* 6*d.* with Monmouthshires from 25*s.* to 27*s.* and bigs from 25*s.* 6*d.* to 27*s.* 6*d.*, while smalls varied from 15*s.* 6*d.* to 19*s.* 6*d.*, according to quality.

Dock Pilot's Tariff.—The Cardiff, Penarth and Barry dock pilots have made an application for their tariff to be extended to include an extra payment of 5*s.* per move for each 250 tons net register of vessels above 3,500 tons net. At present the tariff ranges from 10*s.* per move for boats up to 250 tons net to 2*l.* for those of 3,000 tons net and over. The employers have refused the application but have agreed to meet the men again on the matter. Under the men's proposal the cost of a move of a vessel of 8,000 tons net would be 6*l.* 10*s.* as compared with the present 2*l.* Another matter which has been submitted to a sub-committee of both sides is the fact that of late the pilots have been endeavouring to make manufacturers of small vessels utilise their services for every movement of the vessels in dock. With these vessels it has been the practice for the dock pilots only to "move" the vessel on arrival or sailing.

Iron and Steel Trades.—Though business has been none too active the demand for Welsh tinplates has been rather more brisk on Continental account, while a little business has been placed by South Africa and India. Tinplates have been done at 23*s.* 9*d.* f.o.b., but makers generally demand 24*s.* Steel bars ruled at 8*l.* 18*s.* 9*d.* per ton less 2*s.* 6*d.* rebate to the tinworks, but galvanised sheets were weaker at 16*l.* 17*s.* 6*d.* per ton f.o.b.

GUIDE TO LONDON.—At the present time, when so many visitors from overseas are coming to London in connection with the British Empire Exhibition, the Underground has been well advised in issuing a "Guide to London." This is Guide No. 3, dealing with public buildings, parks, gardens and the riverside. It is independent of two other similar guides, formerly issued by the Underground, dealing with the districts north and those south of the Thames, but forms an interesting complement to them. Several chapters in the third guide have been contributed by well-known authorities. It contains nineteen maps, five photographs, and a series of street plans. It is published for London's Underground by Odham's Press, Limited, Long Acre, W.C.2, at the price of 1*s.* net.

SPERRY GYRO COMPASS EQUIPMENT, S.S. BERENGARIA.—The Anschutz gyro compass has been removed from the Cunard liner Berengaria, and in accordance with the company's practice, the latest type of Sperry compass has been installed. The equipment consists of the master compass—which has been installed in a small compartment in the wheel house—and four repeaters, also a 30-day course recorder, all of which are situated on the bridge. Another repeater has been installed in the wireless room which operates in conjunction with the Marconi direction finder. The equipment also includes the latest auxiliary to the gyro compass—the Sperry gyro pilot—and, consequently, the Berengaria has the distinction of being the greatest British ship to be steered automatically.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The Council of the Institution of Electrical Engineers have made the following award of premiums for papers read during the session 1923–24, or accepted for publication:—The Institution Premium to Lieut.-Col. H. E. O'Brien, D.S.O.; Ayrton Premium to Mr. A. Bachellery; Fahie Premium, to Mr. P. E. Erikson and Mr. R. A. Mack; John Hopkinson Premium, to Mr. A. S. Fitz-Gerald; Kelvin Premium, to Dr. H. M. Barlow; Paris Premium, to Mr. H. Marryat; Webber Premium, to Mr. S. C. Bartholomew; extra premiums, to Dr. A. E. Clayton, Prof. W. Cramp, Miss N. I. Calderwood, Mr. F. J. Teago, and Mr. E. A. Watson; Wireless Premium, to Mr. R. H. Barfield, Mr. C. E. Horton, Mr. E. B. Moullin, and Mr. L. B. Turner, M.A. The award of premiums for students' papers will be announced later.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night, at 6 p.m., at Storey's Gate, S.W. 1. Extra General Meeting. "Third Report of the Steam-Nozzles Research Committee."

THE RADIO SOCIETY OF GREAT BRITAIN: Transmitter and Relay Section. To-night, at 6.30 p.m., at the Institution of Electrical Engineers, Savoy Place, Victoria-embankment, W.C. 2. Informal Meeting. Mr. T. E. Goldup will open a discussion upon the "Design of Transmitting Valves."

THE INSTITUTION OF WELDING ENGINEERS.—Wednesday, May 21, at 8 p.m., at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C. 2. "Power Supply for Electric Welding Operations," by Dr. J. H. Patterson, F.I.C.

THE ROYAL SOCIETY OF ARTS.—Wednesday, May 21, at 8 p.m., at John's Street, Adelphi, W.C. 2. Trueman Wood Lecture, "The Outlook in Chemistry," by Sir William J. Pope, K.B.E., D.Sc., F.R.S.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, May 21, at 5 p.m., at 49, Cromwell Road, South Kensington, S.W.7, "Report on the Phenological Observations in the British Isles from December, 1922, to November, 1923," by J. E. Clark, B.A., B.Sc., I. D. Margary, M.A., and R. Marshall, F.R.A.S. "Note on the unusual order of Flowering of the Hazel in 1924," by E. Kay Robinson, B.E.N.A. "The Distribution of Rainfall over Uganda, with a note on Kenya Colony," by C. E. P. Brooks, M.Sc. Mr. S. C. Russell will exhibit a diagram showing daily records of Well Levels at Chilgrove, Sussex and Detling, Kent, during 1923.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 23, at 9 p.m. The Evening Discourse will be delivered by Dr. Andrew Balfour on "Historical Aspects of Malaria." Afternoon Lecture, Thursday, May 22, at 5.15 p.m. Dr. E. V. Appleton on "Atmospheric Interference in Wireless Telegraphy" (Lecture II).

BRITISH IRON AND STEEL PRODUCTION—The National Federation of Iron and Steel Manufacturers state that the production of pig iron in April amounted to 618,400 tons compared with 668,600 tons in March and 652,200 tons in April, 1923. The number of furnaces in blast remains the same as at the end of March, viz., 194 compared with 202 at the end of February. The output of steel ingots and castings in April amounted to 711,500 tons, a decrease of 105,400 tons compared with March and a decrease compared with April, 1923, when the output amounted to 749,400 tons.

BOILER EFFICIENCY WITH PREHEATED AIR.—In our issue of May 9 we published tests showing the saving in fuel brought about by the installation of a Ljungström air-preheater at the Willesden station of the North Metropolitan Electric Supply Company, the figures having been taken from a recent paper by Mr. L. Marshall Jockel before the Junior Institution of Engineers. We are now informed by Messrs. Howden-Ljungström Preheaters (Land), Limited, of 133, Helen-street, Govan, Glasgow, who hold the rights for the system in question for the British Empire, exclusive of Canada, that, in view of the satisfactory results obtained at Willesden, the Power Company has placed orders for the equipment of three further boilers at Willesden, and seven at Brimsdown with Howden-Ljungström Air Preheaters.

THE HOLMBOE ELECTROLYTIC HYDROGEN GENERATOR.—At the Denofa works of De Nordiske Fabriker, Frederikksstad, Southern Norway, a new plant for the generation of hydrogen and oxygen by the electrolysis of water, that is, diluted caustic alkali, has been in continuous operation since 1919. The arrangement of the cells, which are due to Mr. C. F. Holmboe, managing director of the company, involves several new features. The plant is briefly described by Marc Hanssen, chief engineer of the company, in *Chemistry and Industry* of May 2. The cell room contains 400 cells, which are totally enclosed to avoid all alkali spraying, a gas pressure-equalising device is hence required. The distilled water has to be replenished twice a day; one skilled attendant sees to that and performs also control analyses and looks after the special still in which the distilled water is produced. This still contains in its lower portion a coil, and above that three electrodes of a three-phase system, which is joined to the plant, in addition to direct-current mains for the electrolysis. The weak current passing through to three electrodes evaporates some water; this as steam escapes through a pipe, at the top of the still, into a centrifugal compressor, driven by an electric motor. The compressor sends the compressed steam into the coil of the still, so that the water of the still is preheated. The condensed water leaving the coil of the still enters the coil of another heater and flows then into the tank for the distilled water. The fresh feed water circulates round the coil of the last-mentioned heater and passes from that heater through a front valve into the upper portion of the still. This method of producing distilled water is rather elaborate, but power is cheap at Frederikksstad. The plant absorbs 7,000 kw. direct current and generates 7·3 cub. ft. of hydrogen per kw. hour. The hydrogen is practically of 100 per cent., the oxygen of 99·75 per cent. A small percentage of oxygen in the hydrogen is burnt out by the aid of an electrically-heated catalyst. Most electrolytic hydrogen generators attain an efficiency of nearly 100 per cent.

SELF-CONTAINED EXTRA-HIGH-TENSION SWITCH GEAR AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. FERGUSON, PAILIN, LIMITED, ENGINEERS, MANCHESTER.

(*For Description, see Page* 650.)

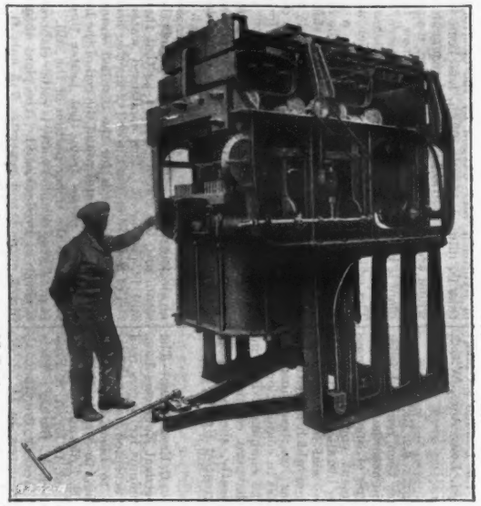


FIG. 1. DUPLEX VERTICAL TYPE SWITCH UNIT.

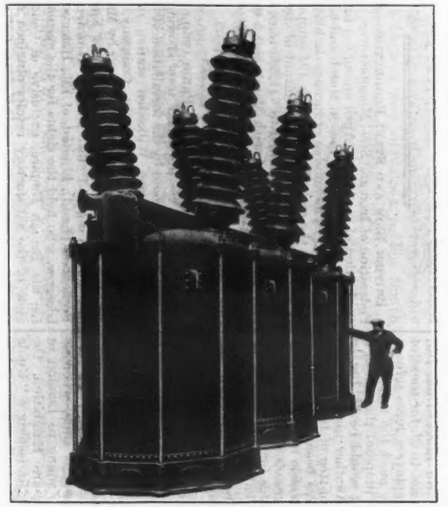


FIG. 3. 135,000-VOLT CIRCUIT BREAKER.

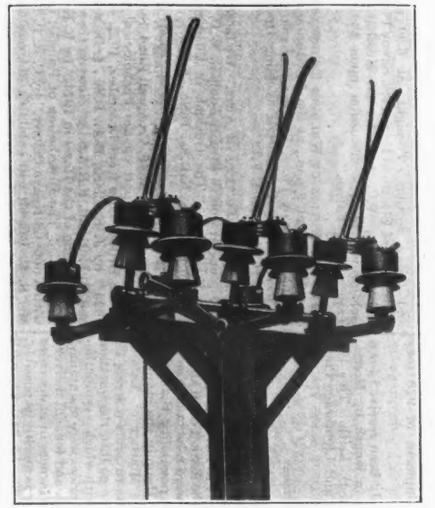


FIG. 5. HORN BREAK ISOLATING SWITCH.

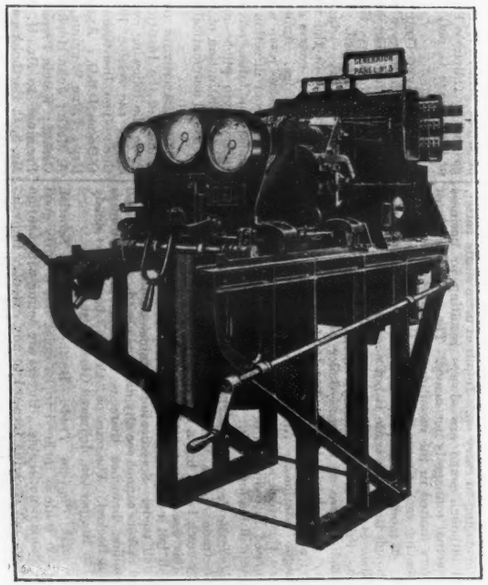


FIG. 2. HORIZONTAL TYPE SWITCH UNIT.

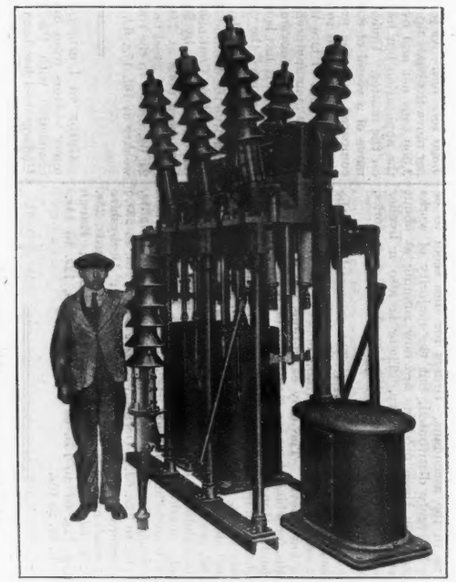


FIG. 4. 44,000-VOLT CIRCUIT BREAKER.

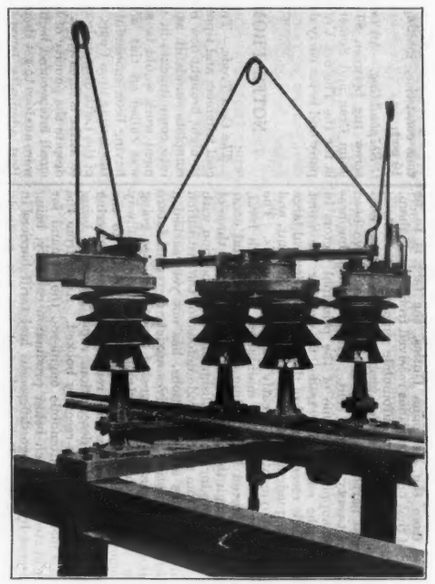


FIG. 6. 88,000-VOLT AIR-BREAK CIRCUIT BREAKER.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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CONTENTS.

	PAGE
The Institution of Mechanical Engineers	627
Science at the British Empire Exhibition.—II (*Illus.*)	627
The Iron and Steel Institute	631
420-H.P. Electric Winder at the British Empire Exhibition (*Illus.*)	634
200-Ton Dragline Excavator for the Sudan (*Illus.*)	636
Industrial Notes	636
Palmer's New Graving Dock at Swansea (*Illus.*)	637
The Late Mr. C. E. L. Brown	637
Notes from Cleveland and the Northern Counties	640
Notes from South Yorkshire	641
Notes from the South-West	641
Notes from the North	641
Notices of Meetings	641
Science, Art and Engineering	643
The First World Power Conference	644
The British Industries Fair at Birmingham	644
Electricity in Shanghai	645
Chemistry and Gas at the British Empire Exhibition	646
Notes	647
The Royal Society Soirée	648
Letters to the Editor.—Air Consumption and Power of Petrol Engines. "The Transverter." Possible New Sources of Trouble from Resonant Vibration	649
Notes on New Books	649
Extra High-Tension Switchgear at the British Empire Exhibition (*Illus.*)	650
Wadkin Tenoning Machine with Internal Drive (*Illus.*)	651
The Production of Large Crystals by Annealing Strained Iron (*Illus.*)	651
Irrigation Pumping Machinery (Gezira Scheme), Sudan (*Illus.*)	654

One Two-Page Plate and Two One-Page Plates.—*PALMER'S NEW GRAVING DOCK AT SWANSEA AND 200-TON DRAGLINE EXCAVATOR FOR USE IN THE SUDAN.*

ENGINEERING.

FRIDAY, MAY 16, 1924.

SCIENCE, ART AND ENGINEERING.

In the days gone by some of the harshest critics of the engineer were to be found amongst the physicists and chemists. The late Professor Tait was particularly prominent amongst these, denouncing the ignorance of the engineers, who supplied him with gas and electric light, rapid and safe transport by sea and by rail, and safeguarded his health by purifying his water supplies and by cleanly and conveniently disposing of his wastes. Of the chemical critics Professor Armstrong is still with us and apparently as convinced as ever that the engineers, who transmit speech over 3,000 miles of sea and electric power over hundreds of miles of difficult country, are devoid both of knowledge and interest in science. As a matter of history, it is true that the great engineers of the past century carried through their transformations of the conditions of civilised life with relatively little assistance from formal science, but to no small extent the fault lay rather with the imperfect development of the latter than with the engineer. Macaulay has commented on the fact that Stonehenge was piled up by painted barbarians who had never heard of the parallelogram of forces, and the engineers who developed the locomotive and marine engine were many of them quite unacquainted with Carnot's theorem, and had they known it might, as conditions then were, have found it more of a hindrance than a help. The fundamental theorem that the efficiency of a reversible engine is independent of the working agent, is, in fact, well calculated to mislead those who have to deal with real engines which are not reversible. With these the efficiency actually realised is intimately bound up with the physical characteristics of the working fluid used. Hence, superheating and compounding, which in a Carnot engine would be of little or no advantage, prove in actual practice to result in very substantial fuel economies.

The engineer, like Kipling's "dusty voorlooper" has too frequently had to "skirmish ahead of the army" of science. This was notably the case in connection with water supplies, since the engineer discovered that water could be satisfactorily purified by sand filtration more than half a century before science was able to explain the process. Again, Lord Kelvin, as he humourously observed, "anticipated" 50 years after its practical application the fact that if a canal boat could be driven at a certain high speed, dependent on the depth of the canal, its resistance would be enormously reduced. This speed is that at which a "solitary wave" would progress along the waterway; and if the boat moves with such a wave there is little dissipation of energy. This explanation of the phenomenon however, followed by many decades its practical exploitations.

No doubt many mistakes were made and many blind alleys fruitlessly explored, some of which at least would never have been entered had those responsible had a firmer grip of established scientific principles. It was not, however, always easy for the older school of engineers to know how much really had been satisfactorily established. The doctrine of the conservation of energy, for instance, did not rank amongst the accepted maxims of science till about 1850. Many physicists of standing refused to accept Joule's results and sneered at the attempt to found a far reaching generalisation on measurements of hundredths of a degree of temperature. It was not till 1847 that Stokes announced his inclination to join the Joulites, and Lord Kelvin did not give in his adhesion till some three years later.

In this connection it is curious to note by what almost imperceptible steps important and novel concepts become common property. One Greek philosopher was accused of impiety for suggesting that the sun was perhaps larger than the whole of Greece. Galileo had a not dissimilar experience, and one hundred years ago the few who argued that the world was really very old were liable to be accused not merely of philosophical error but of moral delinquency. In all these cases, however, the lapse of a few years sufficed to spread the new views not merely amongst the learned but also throughout the commonalty. There was little formal retraction of the older views; human nature is not prone to confessing error, but they simply ceased to be taught, and this was also the case with the view that heat was a material fluid, ingenerable and indestructible. Even after the firm establishment of the new ideas, however, it was long before the detailed developments progressed sufficiently far for them to yield to the practitioner more than guidance of the most general character and, in fact, many ideas prevalent in academic circles, were fallacious. On the Continent, for example, where greater weight was attached to theory than was then customary here, it was long claimed that compounding was useless and that equally good or better results could be obtained in single cylinder engines. In fact, the history of the practical application of thermo-dynamic theory might well serve to illustrate Pope's maxim that a little knowledge is a dangerous thing. To-day, of course, conditions are vastly different, and our knowledge of the physical properties of our working fluids has reached a stage which makes thermo-dynamic theory of the greatest utility both in connection with power production and with refrigerating machinery. If, in this respect, engineering owes much to science, it must, at the same time, be admitted that the debt is reciprocal and that the physicist would fare badly in much of his experimental work without the conveniences with which the engineer has supplied him.

So far as electrical science is concerned, it is interesting to bear in mind that the units used, and the means of exact measurement devised, originated in the demands of the engineer. This was well brought out in the little treatise on electricity and magnetism which Fleeming Jenkin published in the 'seventies of the last century. In the preface to this volume he observed that there were then in vogue two sciences of electricity, that of the text-books and that of the practical man. He further noted that the science of the latter was, so to speak, far more scientific than the science of the text-books. Later on, of course, text-book science caught up with, and in some important directions got ahead of, applied science, with the result that engineers

interested in wireless telegraphy found the theory ready to hand. Naturally, as in all other pioneer work, much still remained to be done, and many phenomena were observed for which no adequate explanation was immediately forthcoming. In this department, at any rate, the engineer and the physicist have proved mutually helpful.

There are still some branches of engineering in which, relatively speaking, theory is about as far advanced as thermodynamics was sixty years ago. This is notably the case in respect to structural design. We have fairly satisfactory theories as to the stresses in perfectly elastic bodies, but these are about as closely akin to our actual materials of construction as Carnot's reversible engine is to actual steam engines. As a consequence, we see not infrequently in text-books criticisms of methods of construction which have proved extremely satisfactory and economical in service. Not many years back a well-known London lecturer on statics used to hold up to the ridicule of his class the girders of Charing Cross bridge, which has successfully carried for over sixty years railway traffic that has steadily increased in intensity and which imposes loads much in excess of those originally contemplated by Sir John Hawkshaw. The basis of the criticism was merely that an exact calculation of the stresses would be difficult, the lecturer not realising that it was also unnecessary. Again, it is exceedingly probable that the designers of the Bear Valley dam in California would never have ventured on such a structure had they been adepts in modern systems of stress analysis. These show that, on the ordinary assumptions, there were tensile stresses near the base far in excess of what any masonry could be expected to carry. Nevertheless, the dam gave excellent service for many years, and was the prototype of a number which have since been erected in New South Wales. The engineers who refused to consider the elastic limit as a satisfactory criterion of strength were long denounced by text-book writers as unscientific, but the real truth of the matter was that the science of the practical bridge and ship constructor was as far ahead of the science of the text-books as was the case with electrical engineering in the times to which Fleeming Jenkin referred in the passages already quoted. This condition is still maintained. We have fairly adequate theories as to stress, but no satisfactory theory as to the relationship between stress and strength.

The engineer has not only been criticised as unscientific, but has been, and still is, accounted inartistic. As a matter of fact, this common criticism is mainly founded on ignorance as deep as that which led a leading architectural journal, at the opening of the Forth Bridge, to deplore the fact that certain of the compression members had not been built with a curved axis. In engineering designs, function fixes form, and when this is the case the result cannot be bad art even if it may not be decorative. We have known an eminent portrait painter, indeed, to assert that he considered a skeleton beautiful, owing to the perfect adaptation of form to function. For our own part, we are not prepared to go to this length, but would merely maintain that, however little it may appeal to the average æsthetic sense, a skeleton, by virtue of this perfect correspondence of form to function, cannot be bad art. Architects have a corresponding maxim that the plan of a building should govern the elevation and not *vice versa*, but the precept seems to be honoured about as often in the breach as in the observance. Such a violation is distinctly bad art, and reduces the designer to the level of a decorator. It is this line of thought which in recent outpourings in the press, seems to maintain that the prime object of a new bridge or roadway is to be decorative, whereas the real function of either is to accommodate traffic, and it is inherently bad art to make this secondary to some temporary taste of the day, or to the desire to estimate the comparative merits of different proposals by the magnitude of the architectural reconstructions involved. This latter seems to be the criterion adopted by the architects who are so strongly opposing the erection of St. Paul's Bridge. Whether the scheme is a good one or not is solely a matter for the traffic authorities. Once these have selected that which best meets transport requirements architects may well be consulted as to details, but they have no valid claim to be heard on the main question as to which, of course, they possess no special competence.

THE FIRST WORLD POWER CONFERENCE.

THE part played by engineering in all its branches and phases at the British Empire Exhibition will be appreciated by all who have visited Wembley, or have studied the special number which we issued describing this section of this vast undertaking, and the various articles in subsequent issues. Naturally, authorities and experts from the whole civilised world will visit Wembley to inspect the wonderful examples of British engineering there displayed. Should they not be brought together by some agency? To this end the idea of a Conference developed, and appropriately the subject of "Power" in all its scientific and commercial aspects, cemented it. A grand council, under the presidency of the Earl of Derby, K.G., was formed and amongst its 60,000 members are included not only the leaders of scientific thought at home, and the Presidents of our leading societies and institutions, but the chairmen and managing directors of many of the leading British engineering concerns. Acting under the auspices of the Grand Council, executive committees have been formed, such as Reception, and Programme Committees.

The invitation to participate in the Conference has been accepted by 31 countries, including our own Dominions and Colonies. In 20 of these 31 countries, national committees have been formed, and they have appointed the official delegates and regulated the submission of papers to the Conference. The remaining countries have appointed delegates. The British Programme Committee, on which the leading scientific societies and Government Departments in Great Britain are well represented, has arranged the programme of papers on behalf of the home interests.

The scope of the papers to be presented is commendably broad, and is defined as considerations of the potential resources of each country in hydro-electric power, oil and minerals; comparisons of experiences in the development of scientific agriculture, irrigation and transportation by land, air and water; conferences of experts in civil, electrical, mechanical, marine and mining engineering; consultations between consumers of power and manufacturers of the means of production, &c. The programme has been classified into five divisions—Power resources, production, distribution, utilisation and general. Each division has sections, thirteen in all, covering the five divisions. For instance, in Division II., Power Production, the five sections B, C, D, E and F, are water-power production, preparation of fuels, steam-power production, internal-combustion engines, and power from other sources.

In Section D, Steam Power Production, there are over twenty papers from seven countries. The leading sections, however, are those concerned with the general subjects of power resources, and power transmission and distribution. The countries apart from Great Britain, which contribute most largely to the 300 papers arranged are, Austria, Germany, Holland, Italy, Norway, Sweden, and the United States of America. Amongst so many papers it is exceedingly difficult to single out any, yet without giving examples it would be impossible to convey the desired impression as to the unique collection of authoritative statements that the proceedings of this conference will form. "The Coal Resources of the World," by Sir Richard Redmayne, "Oil Production in Its Relation to the Resources and Needs of the British Empire," by Sir George Beilby; "Coal Treatment and Carbonisation, with Special Reference to Low Temperature Methods," by Professor H. E. Armstrong; "Steam Turbines," by the Hon. Sir Charles Parsons and Mr. W. L. R. Emmet (two separate papers); "Steam Generation," by Sir James Kemnal; "High-Pressure Water-Tube Boilers," by Mr. O. A. Wiberg, "Air Pre-Heating," by Mr. Fr. Ljungström.

In the section dealing with Internal Combustion Engines, the exponents comprise Mr. James Richardson, Professor Wheeler, Ing. Tosi, Sen. Agnelli, M. Hesselman, Professor E. Hubendick, Prof. Paul Meyer, and Professor Nägel.

Amongst the electrical subjects are papers dealing with "The Transmission and Distribution of Electrical Energy," by Mr. C. H. Merz, and "Recent Practice in Transformer Construction," by Mr. K. E. Eriksson. Messrs. J. S. and W. F. Highfield deal with high-voltage D.C. transmission, and Sir Oliver Lodge with "Electrostatic Precipitation."

The Rt. Hon. Viscount Inchcape will introduce a symposium of twelve papers on "Application of Power to Sea Transport," with a paper on "Shipowners and Shipbuilders." In these papers, naturally the Diesel engine is favoured, four papers being devoted to the subject. Electric ship propulsion will also be dealt with, apart from the foregoing twelve papers, by Commander Robinson, U.S.N. In the section dealing with general matters "Broadcasting: The New Influence" will be discussed by J. C. W. Reith.

Sufficient information will have been given to indicate fully the enormous scope of this coming conference which is provisionally fixed to take place, from Monday, June 30, to Tuesday, July 15, inclusive. Engineering is truly international, yet this is the first time that any such great gathering of experts and authorities has been organised. That it will be a success cannot be questioned. The thorough manner in which all the arrangements have been made, devolving responsibilities to the suitable quarters, to increase efficiency and broaden interest will ensure that. The completeness of the success, however, will depend very largely upon the interest which engineers at home evince in the proceedings. The opportunities afforded by these unions bonded by common technical aims and ambitions of making acquaintances for mutual advancement are unparalleled. Realising that social functions serve this end and are the natural corollary to learned discourses, not only are the meetings interspersed with Receptions, Luncheons and Conversaziones, but at the conclusion of the meetings on Monday and Tuesday, July 14 and 15, as at present provisionally fixed, three tours have been arranged. The first is for Great Britain, the second, for visiting the power stations of France, Switzerland and Italy and the third for the power stations of Scandinavia, with an optional extension to Lapland. In all its aspects the programme is worthy of the occasion and of the British Empire Exhibition.

THE BRITISH INDUSTRIES FAIR AT BIRMINGHAM.

THE British Industries Fair, which opened at Birmingham, on Monday last, the 12 inst., is being held this year some three months later than on previous occasions. The longer hours of daylight thus obtained, and the more genial temperature constitute decided advantages to exhibitors, no less than to visitors. Surprise may be felt that the Fair has been held at all this year, in view of the counter-attraction of the British Empire Exhibition, at Wembley, but there is a good deal to be said in favour of the decision to hold it. The Birmingham Fair is purely a business function, the general public not being admitted, and it would have been a pity to break the sequence and run the risk of forfeiting the connection and goodwill among foreign buyers which the Birmingham Chamber of Commerce has been striving so assiduously to build up for the Fair. It is possible indeed that the effect of the greater exhibition at Wembley in drawing foreign buyers to this country, will react favourably rather than otherwise on the attendance at Birmingham, and we certainly hope that such will be the case. The Birmingham display, especially as regards machinery, has undoubtedly suffered from the competition of Wembley, for few firms have felt justified in incurring the expense of representation at both places. Machinery, however, has never been a very striking feature of the Fair, which has become more and more concerned with the typical Birmingham products, such as brass, copper and aluminium goods, hollow-ware, household utensils, builders' requisites and

domestic appliances generally, and exhibits of this kind are abundantly represented.

As before, the Birmingham Fair is held in the old aerodrome buildings at Castle Bromwich, and better accommodation could hardly be desired. The detailed lighting of the stands again constitutes about the worst advertisement for electric light that could be desired, the Electricity Department of the Birmingham Corporation for some reason or other supplying current at 25 cycles which causes the lamps to give a continuous and almost intolerable flicker. No person who judged electric lighting by the illumination of the stands at the Fair, would be likely to become a consumer. All that is wanted to eliminate the discomfort of exhibitors and visitors is a frequency changer to raise the frequency to the standard, and the provision of such apparatus might be urged upon the Department with propriety by the Electrical Development Association, whose interests are certainly prejudiced by matters as they are. Two only of the three main buildings are occupied this year, and even then there is plenty of room to spare for the reasons we have already indicated. The exhibitors number something less than 300 altogether. The great majority of these show products which do not lend themselves to description in our columns, as they can mostly be classed under the comprehensive name of "ironmongery." We can, therefore, pass them by with the only remark that the artistic excellence of much of the hearth-furniture, lamp fittings, and other domestic hardware shows that our designers and manufacturers can produce articles at least as pleasing to the cultured eye as anything emanating from Continental countries.

The foreign visitor will gain no better idea of the machine tool producing capacity of this country from the Birmingham Fair than from the British Empire Exhibition, for the Machine Tool Trade Association, for reasons which, no doubt, seemed sufficient to them, has prohibited its members from exhibiting at either of these places. There are, nevertheless, some quite interesting tools at Birmingham, though principally of the smaller kinds. The largest display is made by Messrs. Hordern, Mason and Edwards. Limited, of Vesey-street, Birmingham, who exhibit a number of drawing-presses of various sizes and types, for hollow-ware manufacturers, lamp-makers, and sheet-metal workers generally. A pneumatic safety guard for power-presses made by the firm is particularly worthy of notice. It is entirely self-contained, and may be attached to any press by fixing a projecting pin in the slide of the press. This pin actuates a lever as the press descends and moves the piston in an air-compressing cylinder. The air pressure is transmitted to another cylinder, the piston of which moves a guard across the press-table as the slide descends. The action of the guard is silent, and the power is quite sufficient to push the operators' hand out of danger, though not enough, as in some devices, to expose him to the danger of a broken wrist. The whole apparatus is fixed by two screws to the bed of the press, and can be removed and replaced in a few seconds. No adjustments are necessary when it is replaced.

Amateurs and others with small workshops will be interested in the attractve little lathes shown by the Exe Engineering Company, Limited, of Exeter. The firm's standard 2½-in. screw-cutting bench lathe, which is listed at 6*l*. 6*s*. only, will swing work 4½ in. in diameter over the saddle and 5½ in. diameter over the bed, and will take jobs up to 12 in. long between centres. The mandrel has a ⅜-in. clearing hole right through for doing work from the bar. The change wheels supplied enable 24 threads to be cut, ranging from 7 to 60 to the inch, and there is a self-act of 110 per inch in addition. The headstock contains a special clutch device enabling odd pitches to be picked up by the tool with certainty every time when screw-cutting. Stands and treadles are supplied to enable the lathe to be used as an independent tool, and milling attachments and other devices to increase its range of usefulness, are provided as extras. The slide-rest swivels to any angle and can be bolted on three different positions on the saddle. Altogether the design appears to have been thoroughly considered from the points of view both of mechanical soundness and handiness of operation.

Another firm which has set itself to cater for the needs of the small workshop, is Messrs. H. G. L. Young, Limited, of Upper Hollingdean-road, Brighton. This firm is specialising in wood-working machinery for cabinet makers, joiners, camera makers, &c. Bench-mortising machines, spindle-moulding machines, planing and thicknessing machines, circular saw-benches and bench band-sawing machines are all produced at prices well within the reach of the small users for whom they are designed. A bench planing machine with a capacity of 2½ in., with rising and falling table, adjustable guard and fence, is listed at 8*l*. It has dust-proof ball-bearings, ground table and is a really well-made and serviceable machine. A circular saw bench with rising and falling table, adjustable and canting fence, &c., complete with a 12-in. saw, is listed at 15*l*. 10*s*. This machine will take a 4-in. cut, and its table is 24 in. long by 14¾ in. wide. Messrs. T. Chatwin, Limited, of Victoria Works, Birmingham, are showing a simple screwing machine for hand power, which will cut either gas or Whitworth threads on material from 4-in. to 1-in. diameter Threads such as these can, of course, be cut with ordinary stocks and dies, but unless these are operated by reasonably-skilled labour, the result is frequently unsatisfactory, both to the tools and to the work. Moreover, stocks and dies get mislaid and cause waste of time. In the machine of Messrs. Chatwin, the work is gripped in an open top self-centreing vice, which will hold bends and short pieces as well as bars and pipes. The spindle carrying the dies is driven through single-reduction spur gear, so that screwing is easy and the thread cut is always square with the job. The machine can be bolted to a handcart or trestle, if desired.

Messrs. Brown & Ward, Limited, of 27, Great Hampton-street, Birmingham, who are among the few British manufacturers of automatics, are showing an attractive little fully-automatic machine for making articles from rod up to $\frac{5}{16}$-in. diameter, with no further attention than the insertion of a fresh rod as the previous one is used up. The machine is designed for the manufacture of ornamental, handles and knobs, taper-pins, washers, nut-blanks &c., and has been found very suitable for the production of the small articles used in great quantity in connection with wireless apparatus. A larger machine to take rod up to ¾ in. in diameter is also shown, this also being fully automatic in its action. The forming and cutting-off slide has two adjustable tool posts, and a positive stop for forming. The back centre is suitable for holding a box-tool, forming tool or drill, as required. The operations of the machine are all controlled by cams in the usual manner adopted on automatics. Messrs. Brown and Ward, Limited, it should be mentioned, do not confine themselves to the manufacture of automatic machines, their standard productions including capstan lathes, screw-cutting lathes, milling shaping and drilling machines, &c. Messrs. W. H. Royle and Son, of Sedgley-road, Woodsetton, near Dudley, are showing a new design of hacksaw, which has the convenient property of being able to use broken blades. New blades are held in the usual way by pins through their ends, the blades being put under tension by a screw. When a blade breaks, the unbroken end of one piece is held by a pin as before. The other end is slipped between the flat jaws of the holding device, the frame being adjusted in length to allow for this, and it is shown by demonstration on the stand that although the blade is only pinned at one end, and is not under tension, it is held quite rigidly enough to enable quite satisfactory work to be done with it. The design is convenient for use and is suitable for any standard blades.

One of the novelties at the British Industries Fair is a "first aid" motor fire engine on the stand of the Darlaston Galvanised Hollowware Company, Limited, of Booth-street, Darlaston. It is built on the lines of a motor cycle and side-car, the latter carrying as main equipment a chemical extinguisher holding 25 gallons and 25 feet of hose. In addition to this there are two 3-gallon portable extinguishers of the "from" type for use in putting out petrol or oil fires, and another portable extinguisher of similar size filled with the usual liquid. This is quite sufficient for dealing with ordinary small fires. The side-car also carries a collapsible ladder 12 ft. in length. The main chemical extinguisher is supported on trunnions near the centre of its height, and can be inverted with the utmost ease in order to bring it into action. It will throw a jet of chemical liquid for 50 ft. The driver sits on the motor-cycle in the usual way, and another man can ride in a standing position on the back of the side-car flooring. The motor-cycle is a standard "Dunelt" made by Messrs. Dunford and Elliott, Limited, of Bath-street, Birmingham. It has a single cylinder two-stroke engine of 500 c.c. capacity, 85 mm. bore and 88 mm. stroke. The special feature of the engine is a two-diameter piston, by which the scavenging effect is considerably improved. The combination we have described makes a most useful apparatus for reaching fires at the earliest possible moment with all equipment necessary for promptly dealing with the situation, and its price, namely 160*l*. complete, puts it within the reach of any village or small community.

In closing our notice of the Fair it is fitting that mention should be made of the efforts of the Birmingham Chamber of Commerce, not only to attract foreign buyers, but to render them every possible assistance and information on arrival. The manufacturers of the City and district owe a great deal to the work of their organisation whose activities for the advancement of trade might well be emulated in other manufacturing cities. The catalogue of the Fair, with its exhaustive list of articles in three languages and references to every stand upon which articles of each kind can be found, is a model of what such a catalogue should be.

ELECTRICITY IN SHANGHAI.

THE annual reports of the Shanghai Municipal Electricity Department have been for years of a nature to arouse admiration, if not envy, in the minds of station engineers in this country, and to cause ordinary people to wonder when we shall be able to record a corresponding progress in any of our own areas of supply. Shanghai uses coal for generating purposes, as we do, and although it has a large cotton-mill load it cannot have advantages in this respect over certain parts of Lancashire. If Shanghai had no electricity supply at all, or at best a little antiquated plant, one could find many reasons why matters should be thus; but when we find a town in "the unchanging East" easily surpassing any municipal undertaking in this country in output of electricity, we have little cause for self-congratulation. The following figures, taken from Mr. T. H. U. Aldridge's annual report for 1923 on the Shanghai undertaking of which he is the manager and engineer-in-chief speak for themselves:—

Year ending.	Undertaking.	Units Sold for year.	Load Factor per cent.
1923 ..	Shanghai	272,265,861	49·42
,, ..	Manchester	185,638,834	29·41
,, ..	Glasgow	141,919,196	27·95
,, ..	Birmingham	139,468,153	25·26
,, ..	Sheffield	123,438,177	26·96

The Shanghai sales in 1922 amounted to 232,457,631 units, so that an increase of 17·12 per cent. was recorded last year, although the load factor dropped from 51·5 to 49·42 per cent. The capital outlay on the whole undertaking is 4,439,874*l*., and the net profit for 1923, after allowing for debenture interest, depreciation, &c. was 227,232*l*. Of this sum 135,000*l*. was handed over as a contribution to general municipal funds, making a total of 564,000*l*. contributed for that purpose by the electricity undertaking since 1916.

The Shanghai Power Station has a plant capacity of 121,000 kw. including the 20,000 kw. machine which was wrecked on November 15, 1923, and is now being replaced by the makers. The total capacity is made up of two 2,000-kw. machines, one of 5,000 kw., three of 10,000 kw., two of 18,000 kw., two of 20,000 kw., and two house turbines of 3,000 kw. capacity each. Twenty-six boilers are installed. Reference is made in the report to the disaster to the 20,000-kw. set, the shaft of which burst with fatal results, while the

machine was being run, disconnected from its generator, for balancing purposes. The builders of the machine, Messrs. C. A. Parsons and Co., Limited, and the makers of the forging, are in agreement (to use the official words in the report) "that all evidence points conclusively to the accident having been due to a concealed defect (probably a clink) in the interior of the steel forging. The accepted interpretation of the metallurgical term 'clink' is an internal crack due to heating the forging too quickly and may be developed by forging into a cavity of dimensions according to the size of the original crack and the amount of forging which has been put into it. . . . The turbine shaft was found broken into three portions, transversely and lengthwise. . . . When all the shaft parts were co-related a longitudinal irregular fracture was disclosed at the centre of the largest diameter of shaft, indicating that during the process of forging this fault had developed, extending longitudinally and outwards, leaving a comparatively small section of sound material. The nature of the fractures suggests that the final breaking of the shaft was instantaneous and would not give any warning or indication to those responsible for running the plant."

Referring to the working results of the Shanghai undertaking, and taking one candareen at its present value of 0·38 of a penny, we note from Mr. Aldridge's report that the average price obtained per unit sold during 1923 amounted to 1·2*d.* only. Generating costs amounted to 0·48*d.*, distribution to 0·076*d.*; rent, insurance and taxes to 0·023*d.*, management to 0·053*d.*, and depreciation to 0·171*d.*, giving a total cost of 0·83*d.* per unit sold. We are sure that many station engineers in this country would be glad if Mr. Aldridge, in his next report, would give figures of coal consumption per unit sold, the cost of coal per ton, its calorific value, &c., so that they could form an opinion as to the technical results obtained. Shanghai has beaten Manchester in output and in load factor, but we very much doubt whether Mr. Aldridge's new Riverside Station will beat Mr. Pearce's new Barton Station in efficiency. The Barton Station has already maintained an overall efficiency of 20 per cent. for a month's run, and is probably the most efficient station in the world.

CHEMISTRY AND GAS AT THE BRITISH EMPIRE EXHIBITION.

NEXT to the Engineering Section, the completeness of which at the time of the opening made the Palace of Engineering so imposing from the beginning, the Chemical Section could, by the end of April, claim a state of readiness which is noteworthy in exhibition annals. Chemistry and Gas share the Palace of Industry, which is only a little smaller than the Palace of Engineering, with the divisions for cotton, textiles, glass and pottery and food and beverages. Of all these, gas occupies the largest area, viz., 44,000 sq. ft.; chemistry follows with nearly 40,000 sq. ft. The various Sections are divided one from another by two avenues intersecting at right angles. The Chemical Section has been organised by a committee of the Association of British Chemical Manufacturers, under the chairmanship of Mr. W. J. U. Woolcock, with the co-operation of delegates from other institutions and societies interested in chemical science and technology. Within the area at disposal the committee had to accommodate more than a hundred concerns, several of which stand for combinations of firms of world renown, and they have accomplished their task without undue crowding.

It is more difficult for the chemist than it is for the engineer to impress the visitor with the scope and importance of a British industry, which in many fields is the oldest in the world. Models of works would take up too much space and would after all tell little. The chemist has often to content himself with displaying his productions in crystals and bottles, sealed to prevent the escape of vapours; the purity, constancy and strength of the chemicals, the years of research and the time and expense involved in their preparation, have to be taken on trust. He cannot always arrange his exhibits in a pleasing as well as instructive way, enabling the visitor to follow the process applied which may be far more important economically than the particular product. A good deal has, however, been done in this respect, and attendants are generally present to answer inquiries. But there are many exhibits and stands in the Palace of Industry to which this does not apply. Much of the machinery used, the evolution of which is due to the co-operation of chemists, physicists and engineers, is to be found in other sections, and the scientific exhibits illustrating the work of the present generation of British chemists are collected in a group of their own, within the Chemical Sections; we deal with these scientific exhibits in other articles in this and other issues.

The ramifications of chemical manufacture are so diversified that a classification of the exhibits and exhibitors is hardly possible. To begin with heavy chemicals we have first to mention Messrs. Brunner, Mond and Company, of Northwich, whose concern now comprises the Buxton Lime Firms Company, The Castner-Kellner Alkali Company, of Liverpool, Messrs. Chance and Hunt, of London, Electro-Bleach and By-Products, of Middlewich, and the Synthetic Ammonia and Nitrates, Limited, of Billingham, near Stockton-on-Tees. A new product of the lime-kilning works at Buxton is the "limbux," a snow-white slaked lime powder which is recommended for water softening and general purposes; the lime is "mechanically slaked" in revolving screens to ensure uniformity. What the P 84 silicate can do for the hardening of concrete roads and structures is demonstrated at the stand. Half of a concrete slab is impregnated with the silicate; the air-dried slab is then placed in an abrasion machine in which two separate heavy blocks of steel are moved to and fro, one over each half; an air blast forces sand under the rubbing surfaces. In a few minutes the untreated half shows the wear whilst the treated slab, on which three or four coats of silicate have been sprayed, remains practically unattacked. The electrolytic soda of the Middlewich firm is still made by the Hargreaves process of 1900. Acids and solvents come chiefly from the works of Messrs. Chance and Hunt, who also manufacture the Calder-Fox scrubbers for removing acid mists from the acid chambers. The nitrate works at Billingham are now completed.

The panels of the two revolving columns on the equally fine stand of the United Alkali Company, of Liverpool, and other exhibits illustrate processes of tanning, galvanising, dyeing and textile printing. Their "chloros" is a sodium hypochlorite disinfectant which has also been applied with some success against foot and mouth disease; their pure flaky calcium chloride for refrigerating is supplied in easily-closed tins, convenient for intermittent use. Messrs. Spencer, Chapman and Messel display their well-known sulphuric acid of various concentrations in bottles surrounding a flask containing crystals of the anhydride. Messrs. Albright and Wilson, of Oldbury, chiefly show their phosphoric acid and phosphates, in remarkable specimens, and very fine crystals and samples of alum (important as mordants) are exhibited by Messrs. Peter Spence and Sons, of Manchester. One of the alum octahedrons, weighing 200 lb., has taken four years to grow; the titanium salts of the firm are powerful reducing and stripping agents for the tanner.

Messrs. J. White, Ltd., of Glasgow, make a brilliant colour display of chromium preparations, of which they are the largest and oldest manufacturers. The Washington Chemical Company, of County Durham, is still holding its own as manufacturers of only one product, the Pattinson magnesia. In the Chemical Section the Mond Nickel Company limits itself almost to nickel and its isolation by means of nickel carbonyl; the chief exhibit of the firm is in the metallurgical division. One of its specialities and almost a monopoly of Messrs. Laporte, of Luton, is barium peroxide, a purifying and bleaching agent; they also make hydrogen peroxide, a sodium perborate containing 10·4 per cent. of active oxygen, and barium salts which find a wide application. The "Macclesfield" copper sulphate of Messrs. Dennis and Co., of Liverpool, has for more than half a century been valued on the Continent as a spray to kill blight and mildew on vines, potatoes, &c., long before it was utilized in this country, though Messrs. Dennis were the first manufacturers of these beautiful blue crystals, which are made from copper and sulphuric acid, freedom from arsenic being essential.

Much of the salt of the Salt Union, of Liverpool, is utilised for preserving fish on board trawlers and in the fish market, and the "salunol," which the firm recommends for this purpose, is described as "salt chemically united with oxygen," and is used dissolved in water or incorporated in ice. The finest salt of the Murgatroyd Salt Works, of Middlewich and Manchester, will, thanks to its freedom from magnesium chloride, not cake any more than the specially treated ammonium sulphates exhibited by several firms. Messrs. Berk and Co. manufacture, in addition to acids (including accumulator acid) and alkalis, oxides (iron rouge) peroxides, alkaloids and "suder" preparations for the purification of acetylene and for oxy-acetylene welding and case-hardening. The purifier is a kieselguhr-iron oxide mixture said to contain a catalyst for self-regeneration, and the flux a powder into which the hot welding rod or wire should be dipped.

Tar products are chiefly exhibited by the group of firms consisting of the Midland Tar Distillers (with nine works), the South Western Tar Distilleries (five works), and Synthite, Limited, the largest manufacturers of plastic materials made of formaldehyde. The group is associated in their exhibits with Messrs. Burt, Boulton and Haywood (four works), and controls works on the Continent and in Canada. The last-mentioned firm also shows its Silvertown wood preservative and specimens of wood creosoted 70 years ago, and demonstrates the use of the "premier" mill, a kind of colloid mill for disintegrating and emulsifying and for extracting acids from tar and from tissues. The rotor of the mill is a vertical spindle to which a perfectly smooth, truncated cone of steel, tapering downward, is fixed, running at up to 5,000 r.p.m. within a conical ring which it does not touch. The clearance between the two parts may be reduced by means of a micrometer head to 0·003 in., but the adjustment should not be made until after the mill has heated up. The suspension to be dealt with is fed in by gravity and is sucked into the gap between the cones. The white "cyllin" germicide of Messrs. Jeyes is also a mechanical emulsion, in this case of higher phenols. The "Izal" disinfectants are the product of Messrs. Newton Chamber and Co., of Thorncliffe, near Sheffield, whose iron works and collieries date back to 1793. The Gas Light and Coke Company, which draws attention to its naphthalene carbolic acid and cresol, and further to the ease with which its neutral ammonium sulphate can be applied to the soil, is not much younger, 111 years old. The South Metropolitan Gas Company excels in the same products and also in dye intermediates, benzol, pitch and the "Metro" gas lighting specialities.

A confirmation of a good deal that has lately been written on the great advance of the British dye industry can be obtained at Wembley. The British Dyestuffs Corporation prove by their fine display of synthetic colours and their applications, that anything, cotton, wool, silk, leather, even rubber floorcloth, can be dyed in beautiful fast shades; and the exhibits of the British Alizarine Company, the Ajax Aniline Company (leather dyeing a speciality) the Clayton Aniline Company, Colne Valley Dye and Chemical Company, Messrs. Hickson and Partners, Messrs. Halliday and Company, Scottish Dyes, Ltd., and many other firms, are not less noteworthy.

Varnishes, enamels and paints are abundant in the Exhibition, and many artistic effects can be seen on the stands of the Keystone Varnish Company of Hull, and other firms. We notice the oxide paints for wood and metal of Messrs. Quick and Co., Orr's Zinc White, Limited, of Widnes, and the bituminous anti-corrosive and preservative paints of the Kalbitum Paint Company, of Erith. This firm shows only the empty bright black drums, painted with the volatile kalbitum, which is used on all metal structures, including flexible pipes. Charcoal, ordinary and activated, animal and vegetable, is exhibited by Messrs. Thomas

Hill-Jones, Limited, together with their "invicta" bitumens for road making.

The recent development of the British fine chemicals industry has been quite as remarkable as that of the dye-stuffs. That is well exemplified by Messrs. Howards and Sons, of Ilford, who show what an apothecary shop of 1797 looked like and the great variety of modern pharmaceutical, medicinal and photographic products, as well as by firms of world-wide reputation, such as Messrs. Burroughs, Welcome and Co., who have several stands; the British Drug Houses, Limited; Messrs Brake Roberts and Co.; and Boots Pure Drug Company. There seems to be enough strychnine (often coloured to prevent mistakes) and other alkaloids in the Exhibition to poison all London.

That the leading soap makers have long since become leaders in chemical industry is generally recognised. Soap and perfumery are well represented at Wembley. We can only mention Messrs. Crossfield and Sons, of Warrington, and among their products glycerin, caustic soda, silicates, and the new water-softener of the zeolite-permutit type, "doucil," a double sodium-aluminium silicate which can exchange 40 per cent. of its soda against calcium or magnesium.

Only two makers of laboratory apparatus contribute to the Section, Messrs. Baird and Tatlock, prominent in all branches of chemical and biological laboratory work and Messrs. F. E. Becker and Co., whose monel-metal crucibles should be noticed.

Chemical engineering is represented by only one of the leading firms in this branch, Messrs. W. J. Fraser and Co., of Dagenham, whose periodic still we illustrated in our issue of May 4, 1923. Their large vertical autoclave, for pressures of 100 lb. per square inch, and 575 deg. F., is provided with a gear-driven stirrer and heated by two oil coils; the small half-gallon autoclave for 2,000 lb. per square inch, also on the stand, is made in enamelled cast-steel and is heated by an oil jacket, itself gas-heated; the lids are secured by bolts and nuts. We hope to deal later with their new detachable stirrer which is clamped to the vessel in which it is wanted and easily shifted, together with its ¼-h.p. electric motor, over to another vessel. Another conspicuous feature of their stand is a complete model of a Mills-Packard sulphuric acid plant, the lead chambers of which are water-jacketed towers, which occupy little floor space. A model of a copper-still for distillation of essential oils by superheated steam and a filter-press for oil can be seen on the stand of Messrs. Stafford Allen and Sons. We should also have noticed the model of a tar distillery exhibited by the Midland Tar Distillers.

The Nobel Industries, Limited (founded 1918), form, with their thirty odd affiliated companies, a section altogether by themselves, and they are the only representatives of the explosive industry in the Palace. The centre of their large stand is taken up by an elaborate model of a track of hilly country, the many buildings and structures on which visualise the importance of the explosive and allied industries in civil life. There are explosive works, mines, tunnels, tramways and docks which could not have been constructed without explosives, and the manifold other products of the Nobel organisation and the ways in which the ammunition, chemicals, metals, machinery, cycles, plastic cement and varnishes, gas mantles and artificial silks, are produced and utilised, are instructively exemplified by the panels and cases surrounding the large model. We may mention two minor novelties shown by the Nobel group. When tramway tracks intersect at right angles, the rail corners are exposed to severe wear. Thermit, Limited, casts thermit around the whole crossing and fits a steel strip as a replaceable groove-filling into the rail, longer than the distance between the two adjacent crossings; this strip is slightly curved longitudinally, so that the car flange, running on the strip (without risk of derailment) travels up the slope on approaching the crossing and down the slope on receding from it. This tramway crossing, has quite recently been introduced in Paris. The other novelty is the "lightning fastener," a device for rapidly fastening articles of all kinds, such as divided curtains, hoods, boots, tobacco pouches, &c. The edges of the parts are fitted with a series of interlocking members, made of nickel-silver, and are locked by pulling a slider down the seam.

The exhibit of the British Empire Gas Committee likewise forms a section of its own, which is quartered in a building within the building of the Palace of Industry. The house bears the inscription "Gas," and is intended to instruct the public upon the domestic and industrial applications of gas for heat, light and power, and to protest against the domestic burning of soft coal. Edward I and Queen Elizabeth are shown threatening death to malefactors who create a smoke nuisance. The building consists of two main pavilions. The centre of the first is the "rest lounge"; it is surrounded by model rooms devoted to the "seven ages of woman," and also business and consulting rooms. A staff is in attendance. The second pavilion is the demonstration hall, in which aluminium is melted in a gas furnace, and cast into art objects, and various other demonstrations are given in metal-cutting by oxy-coal gas, brazing, case-hardening, annealing, &c. There is a 20 h.p. gas engine, the waste heat of which is utilised in a Spencer-Bonecourt (Kirke) waste-heat boiler, to drive a dynamo and the compressor for the gas furnace, and there are other Spencer-Bonecourt gas-fired boilers and water heaters.

The achievement of the Brentford Gas Company in the illumination of the Amusement Park and parts of the Exhibition grounds deserves special commendation. Wembley was originally supplied by a 15-in. and a 12-in. main from the Harrow works of the company. A further 24-in. main was laid along a lane and was backed by mains from the 30-in. Southall-Ealing trunk. A circular 12-in. main runs round the interior of the Exhibition; two meters, of capacities of 50,000 cub. ft. and 30,000 cub. ft. per hour, have been erected for the 350 1,600 c.p. low-pressure lamps lighting two miles of road. Most of the large columns carry two (some four) 16-burner "Wembley" lamps (of Messrs. Staniforth) of a new construction. The lamps are provided with a centrally-ventilated preheater, instead of the usual plate heater or small heater units. The gas-air mixture is fed to the heater through two limbs of a manifold; the inner four of the burners are fed from the centre of the manifold, the 12 outer burners from a ring; one screw-type regulator controls all the burners. The corrodible parts are made of cast iron. There are altogether 5,000 burners, aggregating 500,000 c.p., and gas is largely used for heat and power in the Exhibition. People are apt to forget in this electrical age that the gas industry remains the chief trustee for the utilisation of the national coal resources. The gas supplied by one London company, representing 15 per cent. of the total town gas output of Great Britain, represent nearly as much energy as all the electric undertakings of the country.

NOTES.

Aeroplane Lift and Drift.

At the Royal Institution on Friday evening last, Professor V. F. K. Bjerknes delivered a lecture on "The Forces which Lift Aeroplanes." In the course of this he showed some highly interesting experiments in hydro-dynamics, most of which had originally been made some 40 years or more ago, but which at that time seemed to have little or no practical bearing. In one set of experiments he employed a couple of thin metal capsules such as are used in aneroid barometers. The interior of each was connected up with a cylinder relatively to which a plunger could be reciprocated so that the flexible sides of the capsules could be sucked in or forced out. Immersing the two in water, in which they were supported by floats with their faces parallel, he showed that when the pulsations of the two were in phase the capsules attracted each other, whilst repulsion was produced when the phases were opposed. In another experiment it was shown that if two cylinders were floated in water with their axes vertical, there was a repulsion between the two when both were set rotating in the same direction, and an attraction when the rotations were in opposite directions. In the remainder of his lecture, the speaker explained the bearing of these experiments on aeroplane lift and drift, but his exposition was so condensed as to incur serious danger of conveying to those not already versed in the Lanchester-Prandtl theory quite erroneous ideas as to certain of the physical phenomena involved. It is to be hoped that this part of the lecture will be amplified before publication in the proceedings of the Institution, so as to eliminate all the pitfalls for the unitiated.

The Geology and Oil Measures of South-West Persia.

The paper which Mr. K. R. Richardson read last Tuesday before the Institution of Petroleum Technologists added a great deal to the information on "The Geology and Oil Measures of South-West Persia," which Messrs. Mayo and Busk had given in a similar paper, six years ago, but it scarcely went beyond the interests of the geologist and prospector. A long belt of petroliferous territory flanks the Persian Gulf and passes to the north-west through Arabistan and Bakhtiari country into Luristan. The boundaries on the south-west are the desert lands of Persia and Mesopotamia, on the north-east the higher Zagros mountains. The limestone arches are deeply cleft transversely as in the Himalayas; Mr. Richardson ascribed this to river erosion rather than to disruption. He considered on petrographic, palæontologic and stratigraphic evidence that the Asmari limestone, which rises in dark, barren whalebacks to heights of 4,500 ft. above sea level, was the productive oil rock of the most important oil field of the Anglo-Persian Oil Company, the Maidan-i-Naftun field. Mr. Cunningham-Craig, Mr. Dewhurst, and other speakers suggested that the oil might have originated in cretaceous shales and have migrated into the Asmari rock which is now the oil reservoir, though that would involve migration through thousands of feet of rock. Unless these rocks were colloidal, the oil Mr. Cunningham-Craig remarked, would leave no traces of its peregrination, Mr. Richardson found the Asmari limestone highly organic and consisting almost entirely of foraminiferal remains; the oil seepages exuded from detrital limestones of the gypseous series. Dolomitisation had transformed the originally hard Asmari limestone into a porous reservoir rock. This dolomitisation and the importance of gypsum for oil rocks were the chief points discussed. Professor Hugo de Böckh, a Hungarian geologist, to whom Mr. Richardson referred in his paper, pointed out that Hoppe-Seiler had proved that gypsum (calcium sulphate) was converted into the carbonate and sulphuretted hydrogen by contact with methane, and further that magnesium chloride, and also magnesium sulphate and ammonia, would dolomitise calcium carbonate, though that required 200 deg. C. in the laboratory under ordinary conditions; aragonite underwent this conversion more easily than calcite—the more common form of calcium carbonate—and there were large occurrences of aragonite and of dolomitisation at Maidan. The production of this remarkably rich oilfield is steadily increasing; it yielded 83,000 tons of oil in 1913, over one million tons by 1919, and 2,941,081 tonsin the years 1922 and 1923. Maidan-i-Naftun Mr. Richardson stated, had never been troubled by water, it had never registered a dry hole, and the limits of the productive area had nowhere been proved yet.

Personal.—We are informed that the name of the Cambridge and Paul Instrument Company, Limited, has now been changed to the Cambridge Instrument Company, Limited, the firm's head office and showrooms remaining at 45, Grosvenor Place, S.W.1, as heretofore, and the business being carried on exactly as in the past.—We learn that Mr. F. M. Jones, B.Sc., has joined the staff of the Vickers-Spearing Boiler Company, Limited, 20, Kingsway, London, W.C.

The Royal Sanitary Institute.—The 35th Congress of the Institute will be held at Liverpool from July 14 to 19. Already 500 delegates from 275 authorities, representing foreign and colonial governments, government departments, county councils, boroughs, urban and rural councils, port sanitary authorities, &c., have been appointed. The Marquess of Salisbury, as President of the Congress, will deliver his address at the inaugural meeting in the St. George's Hall on July 14, at 8.30 p.m. The meetings will be held in the University and the Town Hall. The Health Exhibition will be on a larger scale than usual; exhibits representing all phases of municipal sanitation and domestic comfort will be shown. Visits have been arranged to works and institutions illustrative of the sanitary administration of Liverpool and district, to Widnes, Port Sunlight, Chester, and the Isle of Man. Further data can be obtained from the offices of the Institute, 90, Buckingham Palace Road, S.W. 1.

THE ROYAL SOCIETY SOIRÉE.

ALTHOUGH the Royal Society has taken charge of the scientific exhibits at the British Empire Exhibition, there were quite a number of novelties of interest to the engineer at the first Soirée of the season on Wednesday evening, when Sir Charles Sherrington, M.D., President of the Royal Society, welcomed the Fellows and their guests. Biological exhibits predominated; but, like every other branch of science, biology has long since become dependent upon the assistance of physics and chemistry for experimental research. Two discourses were delivered during the course of the evening. The first, by Mr. F. E. Smith, F.R.S., on "Modern Navigation Devices," dealt with recent advances, which we noticed in our issue of March 7. The second, by Mr. R. Campbell Thompson, was on "Travel and Archæology in Mesopotamia."

The historical exhibits were this year limited to the recently discovered portrait bust in wax (a miniature, about 3 in. high, made in 1788 by S. Percy) of Joseph Priestley, shown in his robe as a Unitarian minister; and to the original silver pocket sundial of the Earl of Orrery (a great-nephew of Robert Boyle), made by L. Rowley, London, 1710, who also constructed the large sundial by which the clock of St. Paul's Cathedral was regulated. Both these exhibits were presented by Mr. George H. Gabb. Two telescopes of Galileo, 3 ft. and 4 ft. long, shown were replicas of the instruments made by Galileo about 1610 and preserved in the Museo di Fisica of Florence, came from the Science Museum, which now collects replicas of new and old instruments of which the originals are not available.

Of astronomical interest were the 16 photographs of three telescopes of different types, made and exhibited by Sir Howard Grubb, F.R.S.; one refracting telescope for Johannesburg, another with dome and rising floor made for Nicolaieff, Russia, and a reflecting telescope for the Simeis Observatory, Crimea, whose dome and platform are operated electrically. Of further astronimical interest was the free pendulum astronomical regulator of Mr. F. Hope-Jones, the pendulum of which is encased in a copper cylinder with glass dome, and has nothing to do but to swing in a vacuum of 3 cm.; it is controlled by the "slave clock" with which it is electrically connected. The phase difference does not exceed 1/240 of a second; the "hit and miss" synchoniser employed is the invention of Mr. W. H. Shortt.

In the third astronomical exhibit the Rev. A. L. Cortie, S.J., of Stonyhurst Observatory, explained by means of striking drawings of sun-spot developments and of many curves of the terrestrial magnetic elements that magnetic storms do not depend upon the areas and the positions of sun-spots, but upon solar activity, which may or may not go together with visible spots. Some great spots have hardly disturbed the elements, while violent magnetic storms and earth currents have occurred when no spots were visible.

Of the engineering exhibits, one of considerable interest and importance is a torsion meter for marine propeller shafts designed by Mr. E. B. Moullin, of the Cambridge University Engineering Laboratory, and made by the Cambridge Instrument Company, Limited, 45, Grosvenor Place, S.W.1. We propose to illustrate and describe the instrument in detail later, but we may now explain that it can be employed to give a mean reading of the torque and also to show its instantaneous values at any part of a revolution. The instrument employs a specially designed variable choking coil fixed to the shaft and to a sleeve attached to the shaft in such a manner that the torsion on the shaft varies the air gap of the choking coil. Alternating current is supplied to the latter by means of slip rings, and the coil is designed so that the root-mean-square value of the current which flows is directly proportioned to the length of the air gap throughout the range of its variation. An ammeter connected in series with the coil, and located in any convenient position, can thus be calibrated to read the mean torque directly, and by placing a Duddell oscillograph in the circuit, the torque fluctuations can be investigated completely. Oscillograph records, exhibited with the instrument, showed very clearly the effects of detonation and misfiring in the cylinders of a marine Diesel engine, and also demonstrated the effects of resonance in the shaft. In one of the records obtained with a Diesel engine running astern at a speed 7 per cent. below the resonance speed of the shaft, the range of stress was shown to be five times the mean stress. The same principle, we may mention, will be employed for the measurement of thrust by the longitudinal compression of a propeller shaft.

Professor G. Stoney exhibited apparatus showing the production of stationary waves in a rotating disc of rubber, and Mr. J. P. Chittenden, of the English Electric Company, Limited, showed, on the same stand, a model used for investigating the critical speeds of shafts. This consisted of a steel shaft $\frac{1}{4}$-in. in diameter and about 15 in. in length, supported in plain bearings at each end and carrying a number of steel loading discs $2\frac{1}{2}$ in. in diameter and $\frac{1}{4}$-in. thick. The shaft, which could be driven by a motor at speeds up to 4,000 r.p.m., carried a plane mirror at one end, and the effects of critical speeds could be studied by the movement, on a translucent screen, of a spot of light reflected from the mirror. As the shaft approached its critical speed, a small circle of light on the screen changed into a long and narrow ellipse, which again contracted into a small circle as the first critical speed was passed. The model has been used for investigating the general problem of the critical speeds of turbine shafts, with particular reference to the effects to be anticipated at half the first critical speed.

Mr. Chittenden also demonstrated the vibration of turbine discs about various nodal diameters by means of a steel disc 1 ft. 9 in. in diameter and $\frac{1}{4}$ in. thick, bolted at its centre to a rigid bedplate and placed horizontally. Near the edge of the disc was an electro-magnet supplied with a direct current which could be interrupted at a rate ranging from 2,000 to 48,000 per minute, so that vibrations could be set up in the disc at any frequency within that range. By varying the frequency of the interruptions the nodal diameters, rendered visible by sand sprinkled on the disc, could be seen to change from 3 to 5. In practice it is desirable to avoid speeds of rotation corresponding to vibrations about two or three nodal diameters, since the amplitudes of these vibrations may be considerable, whereas those about higher numbers of nodal diameters are unimportant.

The method of hardening the ends of standard gauges, shown by Messrs. Bloxam and Buckley, of the National Physical Laboratory, was referred to on page 156 of our last volume, but we may remind our readers that the object of hardening the ends only is to reduce the effects of the inequalities in the coefficients of thermal expansion which result from the hardening process. For this purpose, a heavy current is passed into one end of the gauge through three graphite resisters in series. The contact resistance at the two surfaces of the intermediate graphite resister, causes a very considerable heating effect, and the heat conducted to the end of the gauge is sufficient to raise it to a temperature slightly above the critical. The breaking of the current is arranged to allow the gauge to fall into cold water and the heated portion is consequently hardened by the quenching action. With circular gauges 1 in. in diameter, a current of 750 amperes, flowing for about 2 minutes, is found to harden the steel to a depth of about $\frac{1}{4}$ in. from the end.

The Science Museum also exhibited the results of the remarkable determinations of gravitation at sea which Dr. N. Meinesz—who was present—of the Netherlands Geodetic Committee, took in September to December last year on board the submarine K.11 on a journey from Holland to Java, during which he spent 50 days actually in the submarine. The determinations are made by means of a Stückrath pendulum, the pillar of which supports two pairs of half-second pendulums, swinging—in a vacuum in shore installations, but not at sea—in two planes at right angles to one another. By means of a prism on the pillar and of mirrors the beams of two lamps are thrown on a photographic film recording the curves of the simultaneous oscillations of the two pairs of pendulums. As long as the ship keeps steady the two rays remain parallel; if the ship moves the curves diverge; a submarine was chosen as being steadier than a ship. The pendulums are mounted in a cradle to reduce the rolling, but the ship's movements have to be eliminated by mathematical analysis. The results confirm the isostacy of the earth on the great oceans; that is, there must be earth of greater density than the normal under the lighter water. No correlation could be traced between the depth of the ocean and gravity variation.

Sir George Greenhill, F.R.S., showed a simple pendulum suitable for elementary instruction as well as for exact experiment, partly to demonstrate that the simple pendulums of text books, consisting of a heavy ball suspended by a string, is not simple. His pendulum consists of a sphere provided with a diametrical hole through which a string is passed; the string is held at two points in a horizontal plane. The length l of the equivalent pendulum would be the depth of the centre of the sphere below the line of the supports, and l is regulated by the distance between the supports, no correction being, in this pendulum, required for the centre of oscillation, which is not easily determined in the ordinary ball pendulum. In Sir George's second exhibit, echelon pulleys, two sheaves were so swivelled as to take up a position automatically with the parts of the five cords all parallel; the device illustrates the exact theory of pulley tackle and is suitable also for practical application on a large scale.

Sir William Bragg's specimens of the crystalline structure of metal foils were mentioned in our notice of his Royal Institution discourse on recent advances in X-ray work (ENGINEERING, February 15, p. 204). The all-metal annular-jet vacuum pump of Dr. Kaye and Mr. I. Backhurst, of the National Physical Laboratory, has also been described by us*, in connection with Sir E. Rutherford's lectures on gas properties in vacua. At the Soirée, the pump was joined to an X-ray bulb, and it reduced the gas pressure in that bulb within a few seconds down to X-ray work rarefaction. The annular jet has a total area of nearly 3 sq. cms. and the speed of working can, owing to this large active area, be raised to 7,000 cub. cm. per second. The demonstration of the measurement of the natural lighting of a room also illustrates work of the National Physical Laboratory. Illumination of a room is generally expressed as the ratio of daylight (itself constantly varying) to the illumination which would exist if the room and its obstructions were entirely removed. This ratio (daylight factor) is commonly of the order of 2 per cent. to 10 per cent. In the apparatus shown by Mr. Taylor and Mr. Cornford, the observer looks through an eye-piece down an inclined tube on to a horizontal (or vertical) "card" (or plate) made of opal glass, which receives the light inside the room. By means of a mirror the light of the sky is thrown on the outer portion of the card, and the two illuminations of the centre and of the outer portion of the card, are balanced by adjusting an iris diaphragm, which limits the amount of daylight admitted. No artificial source of light is wanted in this device.

(To be continued.)

SWEDISH NAVY.—The Swedish Ministry for the Marine has recently reported that the ice-breakers available at the Baltic ports would be of very little use in war time, and have advocated the building of a group of armed, state-owned, ice-breakers. The ships are to be 242 ft. long and to have a beam of 67 ft. Their draught aft (whilst ice-breaking) will be 25 ft.; they will have engines of 5,500 indicated horse-power. During March and April the Swedish fleet carried out manœuvres and practices. The following ships took part: Drottning Victoria and Gustav V (coast-defence ships), Clas Fleming (mine-layer), Psilander (torpedo cruiser), nine torpedo boats, four submarines, five armed launches.

FINLAND NAVY.—The Finnish Parliamentary Commission for Coast Defence recently drew up two projects of national defence. The first cost three, and the second two, milliards of marks; the Council of State rejected both on the plea that the country could not afford them. The committee have now drawn up a fresh scheme, which they term a "minimum programme." It makes provision for a naval air service and a large amount of mining material, and is to cost 300 million marks, of which 240 are to be allocated to building a naval force of three gunboats (3,000 tons each), a submarine chaser, eight submarines, and 40 motor torpedo boats. The committee urge that this naval force should be completed in eight years.

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* *See* page 366 *ante*.

LETTERS TO THE EDITOR.

"AIR CONSUMPTION AND POWER OF PETROL ENGINES."

TO THE EDITOR OF ENGINEERING.

SIR,—I have only just seen Mr. Hodgson's letter in your issue of May 2 on the above matter. While I appreciate the large amount of work which Mr. Hodgson has done in connection with the measurement of air and other gases, and also liquids, and while I quite agree that in some cases the square-edged orifice (for the reasons he gives) may be preferred, I think that, to those who attended the Institution when Dr. Moss's paper was read, and who heard the discussion, it will be clear that Mr. Hodgson has taken my remarks regarding parabolic nozzles out of their context.

My recommendations of the parabolic nozzle—in my remarks on that paper—were limited to cases where there is a slight pressure difference. I referred to my paper read before the Institution of Mechanical Engineers, on "The Testing of Air Compressors," on November 22 last, and pointed out that with a well-designed nozzle of that form the coefficient was very close to unity. I further pointed out that where the pressure difference is very slight, the effect of temperature in the calculations could be ignored.

Under these conditions the application of a simple hydraulic formula would then enable experimenters to arrive at an approximately accurate value for the exact volume of gas passing by using simple calculations which do not involve the use of exponential equations. I cannot find that there is anything in Mr. Hodgson's letter to you which casts any doubt on the correctness of this statement.

Yours faithfully,

W. REAVELL.

Ranelagh Works, Ipswich.
May 12, 1924.

THE "TRANSVERTER."

TO THE EDITOR OF ENGINEERING.

SIR,—It is, I am sure, with the greatest interest that a large number of the members of the electrical profession will have perused the description relating to Messrs. Highfield and Calverley's transverter which appeared in your paper, and the enconiums which have been bestowed upon the inventors are thoroughly well deserved, for it is clear that the machine must have involved the solution of a tremendous number of new problems and difficulties which at first sight appeared almost insuperable. It must be very gratifying also to the inventors to have been able to obtain such a high overall efficiency as they have done.

While, however, I am prepared to grant that the transverter supplies an invaluable means for the transmission of comparatively small powers over extremely long distances, I think we must be careful not to be led away into believing that it will compete seriously with static step-up and step-down alternating current transformers for the transmission of power over great distances in large bulk.

I note that Mr. Roger Smith, in his references to the machine a year and a-half ago, did not go beyond suggesting that the 2,000-kw. size would be a standard size for railway transmissions, and he spoke of a transmission of 25,000 kw. over a distance of 50 miles. Taking this as our basis, it would therefore require a "fleet" of thirteen 2,000-kw. transverters at the generating station and, say, three at each of four sub-stations for such a transmission.

Efficiency.—The first thing that strikes one is that the transverter introduces a gratuitous extra loss of 3 per cent. at the sending end, or, say, 6 per cent. at the sending and receiving ends combined, over that of large static transformers. Now, in the paper which the writer read before the Institution of Electrical Engineers, he showed that every 1 per cent. loss on a 25,000-kw. transmission would be worth a sum of, roughly, 39,000*l.* when capitalised; consequently, the above 6 per cent. loss represents a sum of 234,000*l.*

Attendance.—The next point that strikes one is that the cost of attendance for all these 26 machines, 260 commutators, and 468 small single-phase transformers, each transformer having ten windings differing in pressure by 100,000 volts from one another, will be very serious; also that the breakdown of any one of these 4,680 windings will put a transverter out of action. To attend properly to all these commutators and transformers will require a staff quite comparable with that employed in rotary converter sub-stations, and a stand-by charge of some 10*s.* per kilowatt per annum will be necessary in the sub-stations at least, and a further sum of 5*s.* per kilowatt per annum for the generating station. A total annual sum of some 18,000*l.* per annum would therefore have to be paid in wages. This, capitalised at 5 per cent., represents 360,000*l.*

Extra Capital Cost.—The next item that strikes one is that as the capital cost of the transverter is probably of the order of 5*l.* per kw., there will be an expenditure of some 4*l.* 10*s.* per kw. in excess of what there would be if large static A.C. transformers were used (to say nothing of the great increase in the floor space required in the generating stations and sub-stations). Now 25,000 kw. at 4½*l.* per kw. represents 112,500*l.* extra capital outlay, which must be doubled, because they are required at the receiving end also, giving a total of 225,000*l.* extra capital outlay.

Maintenance.—A fourth item, and one which must not be overlooked, is the extra cost of maintenance of 468 transformers and 260 commutators. If we take 10 per cent. per annum on 225,000*l.*, we get 22,500*l.* per annum, which, capitalised at 5 per cent., is 450,000*l.*

Summation of Charges.—Adding together, therefore, the above capitalised sums, which are debitable to the use of the transverter as against the use of plain A.C. static transformers, we have the following:—

£.
234,000
360,000
225,000
450,000
1,269,000

This represents then (neglecting for the moment the extra dielectric losses) the sum which could be spent upon A.C. cables for the transmission of the above power. I do not think that our cable companies will object to provide the necessary cables for a sum considerably less than half of this.

General.—It seems to me that the transverter has a very great field, *and one that is exclusively its own,* in the interlinking of generating stations whose frequencies differ, as well as the transmission of comparatively small amounts of power over very great distance on railway work—though in the latter case there may be two opinions as to the extent to which this can economically be done; but I do not feel that, until something can be invented which has an efficiency equal to the static transformer (on a big scale), and which requires no more attention, and, further, whose capital outlay is no greater than the latter, we have yet reached the ideal; it may be that we shall never reach it, but in any case Messrs. Highfield and Calverley are to be congratulated on the great step in advance which they have made.

I ought not to close this letter, however, without saying that I have serious misgivings as to the advisability of having transformers, which may have to be lifted out of their cases, in an open engine room, with all the drippings of oil and mess which this involves. It is the experience of those who are operating transformers at 33,000 volts in super-stations that they are very glad to have them in brick cubicles with fireproof doors; and the thought of 234 single-phase transformers at 100,000 volts in an open engine room is, to say the least, rather a startling proposition. I appreciate that, on account of the immense number of connections, it is almost impossible to separate the transformers from the rotating machine.

A. M. TAYLOR, Major.

Slade Lodge, Erdington, Birmingham.
May 10, 1924.

POSSIBLE NEW SOURCES OF TROUBLE FROM RESONANT VIBRATION.

TO THE EDITOR OF ENGINEERING.

Sir,—We think that there is a source of vibration which has not received the attention it deserves, and which may possibly account for a class of rather obscure trouble which defies the usual methods of analysis. The simple theory of resonant vibration is very generally understood. If a recurrent disturbing force acts on any mass it will set it into vibration with an amplitude dependent, amongst other things, on the magnitude of the disturbing force and inversely on the mass. If the mass is associated with a force restoring it to its position of rest then it will have a natural frequency of its own, and will be set into *resonant* vibration when the disturbing force has the same frequency. The amplitude will then be increased to an extent only limited by friction.

In either case the frequency of the vibration will in general be that of the disturbing force, though it may be higher in a definite multiple. A disturbing force of higher frequency than that of the system will not cause resonant vibration. It is generally assumed that to set a system into resonant vibration it is necessary to have a disturbing force of a frequency either equal to the natural frequency of the system or lower than it in a definite sub-multiple. A disturbing force of any higher frequency will not so act. But a single blow or impulse will set the system into vibration at its own natural frequency whether it is stationary or revolving or vibrating at some other frequency under forced vibration from another disturbing force. This vibration will in general die out, due to friction or damping, but if, before it has died out, the blow is repeated, the vibration is restarted, still at the system's own frequency but with an amplitude depending on the phase of the motion at the instant of the second blow.

If the blows are repeated regularly this may cause the phenomenon of beats. In this way a disturbing force consisting of periodically repeated impulses may have a different effect from one varying harmonically. This is due to the system being left free, in the intervals between the blows, to follow its own inclinations. But there is still another way in which the system can be set into resonant vibration, this time by a disturbing force of no determinate frequency but one capable of setting up vibrations at any frequency if the system acted on has a sufficiently definite frequency of its own which it can impose on the happenings.

This may be made clearer by examples: A bow is drawn at a perfectly uniform speed over a fiddle-string and sets it into resonant vibration, the frequency of which is determined by the length of the string, its tension and mass alone; alter any of these conditions and the bow calls forth the frequency appropriate to the new conditions with equal facility as it did under the old, nothing being altered in the bowing. A clock spring and escapement will keep any length of pendulum vibrating at the pendulum's own frequency. The wind from the same bellows will evoke different notes from the different organ pipes. This power, either of a system capable of vibration, of compelling a disturbing force to its own natural frequency, or of a disturbing force of indeterminate frequency of adapting itself to supplying energy at the frequency of any system it chances to act on, has not had the attention it deserves. The fact of its existence seems greatly to increase the danger of vibration troubles. Without it a system capable of troublesome vibration has been considered safe unless a definite disturbing force of a frequency very near to its own was known to exist; under this new view such a system is a continual danger in that it is capable of seducing an otherwise perfectly innocuous source of energy and using it for its own nefarious ends.

The moral of it all is that engineers must not leave such sources of trouble about loose, but must effectively muzzle them by suitable damping.

Yours faithfully,

JULIUS FRITH.
F. BUCKINGHAM.

33, Brazennose-street, Manchester.
May 10, 1924.

NOTES ON NEW BOOKS.

DURING the last dozen years the manufacture of electrical equipment for automobiles has become an important industry, and one that is worthy of detailed attention by students of electricity. Therefore, it is not surprising that in the United States of America, where the industry had its birth and has attained large dimensions, a number of books have been published dealing with the subject, one of the latest being a treatise by Mr. Paul MacDowell Stone entitled "*Electricity and its Applications to Automotive Vehicles*" (London: George Allen and Unwin, Limited, price 18*s.* net). This volume of over 800 pages, containing nearly 400 illustrations, of which many are wiring diagrams of various lighting and starting systems, generally resembles a certain class of quasi-scientific literature turned out in large quantities in America for the information of men of the garage mechanic or correspondence course student types. No attention is given to the design or manufacture of the apparatus dealt with, but fairly detailed descriptions are given of every item of electrical equipment commonly found on cars of American origin. Preparatory to this, the author deals fairly clearly and in a practical manner with the elements of magnetism and electricity as applied to the problem in hand, treating the subjects in simple language but at the cost of a good deal of rather unnecessary repetition. Primary and secondary batteries, ignition systems both by induction coil and by magneto, generators, starting motors instruments and switch gear, together with miscellaneous items such as horns and gear changing devices, are described in an understandable manner, although the author confines himself entirely to American practice. Considering that something like half the book is devoted to descriptions of various proprietary apparatus and systems, it is somewhat surprising to note that not a single reference is made to any British or Continental car or manufacturer, although the work of the leading manufacturers on this side of the Atlantic is at least equal in design and general performance to anything

made in America. The idiom throughout is, of course, American, as witness the chapter on "Trouble Shooting," which is quite useful. There are certain rather unhappily phrased statements which may cause some confusion of thought, such as "there are two volumes of hydrogen to one of oxygen in water," it being more usual to say "atoms" than "volumes." The statement that "The only way to measure the capacity of a condenser is to use what is known as a 'capacity meter'" will hardly bear investigation, while even in America, where the gallon is one of only 231 cub. in., it would be surprising "if a quart of water should weigh 2 lb. when cold." Apart from such peculiarities, the book should prove useful to mechanics and others in its country of origin, but it cannot seriously be recommended to those in search of knowledge in this country.

When Professor H. Dubbel compiled the first edition of his German pocket-book for engine construction, he was guided by the idea that the subject called for his paying particular attention to the general sections on mathematics and mechanics, and to a general comprehensive treatment of interrelated problems and good diagrams, but not for much constructive detail, since the specialist would hardly consult a pocket-book as to his own branch. The author has adhered to this view in the fourth edition of his "*Taschenbuch für den Maschinenbau*" (Berlin: Julius Springer; 2 vols; price 4.30 dollars), the 1,728 pages of which are illustrated by 2,786 text-figures. The sections on hoisting and transport, toothed-gearing, pumps and water turbines and turbo-compressors are re-written, mostly by his collaborators, while Professor Dubbel has contributed, fully or partly, some of the main chapters on parts of engines, steam generation, prime movers and machine tools. The index would be good if it were not confined to subject-matter; there is no name in it. The section on electro-technics might well have been omitted to obtain a little more space, for instance, for the section on materials, which is too short.

SELF-CONTAINED EXTRA-HIGH-TENSION SWITCH GEAR.

ONE of the characteristic features of many of the types of high tension switch gear which have been developed during recent years is that the various panels or switches are self-contained and require no flat boards or cubicle structures for their installation, while another quite usual feature of this modern gear lies in the fact that much of it is of ironclad construction. This latter characteristic, however, is probably not quite so general as the other and does not, for instance, cover the modern form of high tension air-break circuit breaker intended in general for use in the open. We have accordingly adopted the former term to cover the selection which we have made from the very extensive and varied display of switch gear which is being shown at the British Empire Exhibition by Messrs. Ferguson, Pailin, Ltd., of Higher Openshaw, Manchester. Messrs. Ferguson, Pailin's stand is of great interest, not only as illustrating the range of modern high-tension and extra high-tension switch-gear construction, but as at the same time serving as an illustration of the fact that manufacturers in this country are taking their proper place in connection with switch gear and that the time is past when it was considered necessary that extra-high tension schemes in the British Empire should at least have the switch-gear supplied from some foreign country.

We illustrate examples from Messrs. Ferguson, Pailin's display in Fig. 1 to Fig. 6, on page 642, and as this gear is of various classes and types it will be well if we deal with the various examples independently one from the other. Turning then to Fig. 1 it will at once be seen that this gear is of the self-contained ironclad type, intended for power station installation, the development of which has taken place practically entirely in this country. The actual gear with which we are dealing is, however, of novel form, in that the circuit-breakers are placed below the bus-bar chamber instead of in front of it, as in the more usual horizontal draw-out type of gear. The vertical arrangement economises floor space and lends itself particularly well to the class of gear illustrated in Fig. 1. This is of the duplicate bus-bar type and the oil circuit-breaker is virtually two breakers, one for each set of bars. Normally, when one switch is in, the other is out and the two are only in together when the bus bars are being run coupled. Each of the two breakers has its own system of operating levers, and each is provided with its own closing solenoids and shunt trip coil. The switches are, of course, arranged for operation from a distance and normally the selection of bus bars is done from the control board. The double switch arrangement practically enables one switch to be used as a stand-by for the other, in case it has opened on a short circuit and time is not available for examination of the arcing contacts. The arrangement also allows a feeder which has been down for repairs to be connected to the "hospital" bars temporarily until it has been tried out, after which transference may easily be made to the main bars.

Each unit has its own motor-operated raising and lowering gear for the circuit breaker, actuated through a worm gear. The arrangement allows either the tank or the complete circuit breaker to be lowered and removed from the unit. The breaker can be isolated and its tank lowered in three minutes without labour on the part of the attendant. The bus-bar contacts are automatically screened when the breaker is isolated. The potential transformers are mounted in a separate oil tank at the back, which may be lowered in the same manner as the circuit breaker. In this case the lowering gear is a hand-operated winch. Full interlocking arrangements are fitted in connection with the gear, which is built for voltages of 11,000, 22,000 and 33,000, the current capacity in the first case being 2,000 amps. and in the last 750 amps.

The gear shown in Fig. 2 is an example of armour-clad compound-filled switch gear of the more usual horizontal draw-out type, with its bus bars carried at the back. The gear is made for pressures up to 11,000 volts. As will be seen from the figure, two sets of bus bars are arranged for, and the gear embodies a manually operated oil-immersed selector switch, by means of which the oil circuit breaker may be connected to either set of bars. The selector switch is mounted below the bus bar chambers, and a mechanical indicating device is provided which shows to which set of bus bars the breaker is connected. It will be clear that the method of changing over from one set of bus bars to the other by this gear is very convenient and safe. Interlocks are provided on the selector switch and may be arranged so that the unit may be used either as a bus-bar selector and coupler, or as a selector only. The gear can be fitted either for electrical distance operation or mechanical control, and is fitted with the usual transformers for instrument and relay control. The breaker is moved forward on its rails, when it is desired to remove it from all connection with the bus bars, by means of a rack and pinion arrangement which can be seen in Fig. 2.

In Figs. 3 and 4 are illustrated two examples of Messrs. Ferguson, Pailin's self-contained circuit breakers for very high voltage use. Both the examples are primarily intended for outdoor service. The breaker shown in Fig. 3 is intended for use on circuits up to 135,000 volts. It has a current-carrying capacity of 600 amperes, but as will be understood this capacity is dictated rather by mechanical considerations than by any probability that it will be required continuously to carry currents of that order. As will be seen from the figure, the breaker is totally enclosed, the compound-filled condenser terminals being shrouded by porcelain petticoats to give adequate protection from rain or snow. The portion of the terminal which lies under the cover is provided with a plain porcelain shroud protecting the insulation from carbon deposition due to the arc. The current transformers for tripping or metering are mounted on the terminals immediately below the top plate of the breaker.

The main breaker contacts are enclosed in electrostatic shields which diminish the stresses on the oil, the fixed contacts being of the self-aligning finger pattern, while the moving contacts are of the inverted V type and are carried in a bakelised contact bar which is supported by two bakelised cross rods, these rods being guided at each side of the tank by sleeves which slide on vertical rods. Accelerating springs are provided at the top of each rod and retardation is ensured by an oil dash pot at the bottom. Auxiliary arcing contacts are provided, the upper part of which is carried at the end of a vertical spring-loaded telescoping rod. These contacts latch with the lower arcing contacts which are fitted on the main contact bar. When the breaker opens, the upper contacts are carried down until the telescopic rods are extended and the springs fully loaded. The contacts then unlatch and spring back giving a high speed of break.

The top plate of the breaker is made of steel and the tank, which is 5 ft. 3 in. in diameter, is made from $\frac{3}{8}$ in. steel plate. A manhole is provided in the top plate for inspection and repair. The tank is secured to the top plate by a steel cradle and ten $1\frac{1}{4}$ in. diameter bolts, the arrangement being clearly shown in Fig. 3. The operating mechanism is accommodated underneath the top plate, and when three breakers are connected together to form a three-pole unit, as in Fig. 3, no gases can escape from one tank to the next by way of the mechanism chamber. Oil displaced by the operation of the breaker is trapped in a vent provided with baffles, which, however, allows gases to escape by a vent pipe which projects downwards. Ingress of foreign matter is prevented by a wire-gauze screen at the end of the pipe. The breaker may be either mechanically or electrically operated.

The gear shown in Fig. 4 is generally of the same class as that shown in Fig. 3, but is intended for somewhat lower voltage service, being built for use up to 44,000 volts. As in the case of the higher voltage unit, it is built in single phase units which are mounted on a channel and tubular framework to constitute a multi-phase breaker. In this example the top cover is a ribbed casting, the operating mechanism being accommodated in a dome formed above it. The casting supports the bakelite condenser terminals which are shrouded with porcelain shells which afford protection against rain and snow. The tank is cylindrical, 22 in. in diameter and has a dished bottom. It is held between a cast-steel cradle and the top casting by four $1\frac{1}{4}$ in. diameter bolts, which are provided with knuckle joints to facilitate removal of the tank. Ventilating arrangements are provided as in the 135,000 volt breaker. The solenoid operating gear is totally enclosed and is situated on the floor at one end of the breaker, as shown in Fig. 4.

Our two remaining illustrations, Figs. 5 and 6, show air-break high-voltage switches, intended for mounting on pole tops, or steel framework, for outdoor service. The first of the two examples, that shown in Fig. 5, is a 3-pole switch primarily designed for disconnecting purposes, but capable of breaking low loads or small charging currents. The moving part of the switch consists of three brass contacts carried on insulators which are secured to a longitudinal spindle, or rocking beam, which is operated from ground level by wire ropes. The arrangement will be clear from Fig. 5. The rope is carried round a drum at the bottom of the pole and stops are fitted to limit the movement of the rocking beam. The fixed contacts, which are carried on the row of insulators to the right-hand side of Fig. 5, are of the copper leaf type. As will be clear from the figure, horn breaks are fitted to the switch, a hair-pin shaped contact connected to the moving contact engaging with a vertical rod carried by the fixed contact. The entry of this fixed arcing rod between the legs of the hair-pin moving contact rod maintains a good contact on the horns. The proper entry of the hair-pins over the fixed rods is ensured by curved guides carried by the second set of fixed insulators. The arrangement will be clear from the figure. The ample clearance allowed, the vertical displacement of the arcs and the alignment maintained by the construction, ensures that the arcs will not strike between phases or between phase and earth.

The final illustration, Fig. 6, shows an air-break circuit breaker of somewhat different construction, which is made for voltages up to 88,000. The construction is substantially the same for all ranges of voltages from 11,000 to 88,000, except that in the highest voltage breakers two breaks per pole are provided. The arrangement consists of a copper tube contact arm carried on two porcelain insulators, which are mounted on a channel-iron base. The whole of this arrangement is carried on a vertical spindle supported in a brass bushing, and contact is made or broken by the swinging of this contact arm in a horizontal plane. The fixed contacts are laminated copper brushes which are protected from the weather by a steel hood. A horn break is fitted as shown in the figure, this part of the gear being made of steel wire, which is adjusted so that the first part of the movement of the breaker on opening is sharp and decided. The motion continues under the action of a falling weight, and the final part of the travel of the moving contact is rapid but smooth. The breaker is fitted with an automatic solenoid trip, but may also be operated by hand.

SWEDISH STATE TESTING INSTITUTE.—The commercial Secretary at Stockholm reports that British exporters can submit samples of any materials concerning which there may be any doubt as to their conforming technically with Swedish import regulations for examination to the Swedish Government Testing Institute, Stockholm. The Institute was opened in 1920 with new and modern laboratories to continue and develop the work of the former testing institute of the Technical High School, which at the same time ceased to exist. The aim and work of the Institute is to carry out impartial and expert testing and examination of industrial raw products and finished goods as to their mechanical, physical, and chemical properties. The work for all clients is paid for according to a tariff schedule. The Institute is organised in five sections for the following subjects:—Mechanical testing. Microscopic and thermal investigations of metals and inspection of steelworks products. Testing of building materials, such as cement, concrete, &c. Physical investigations of electric and other materials and instruments. Chemical analysis and sampling of cellulose, pulp, paper, coal, oils, leather, &c. The Institute is managed by a board of directors who are responsible to the Government, and it has a working staff of skilled experts. All results of tests for clients are strictly confidential. Information as to service and charges is given on request. The address is The Government Testing Institute, Stockholm, Sweden.

TENONING MACHINE WITH INTERNAL DRIVE.

CONSTRUCTED BY MESSRS. WADKIN AND COMPANY, ENGINEERS, LEICESTER.

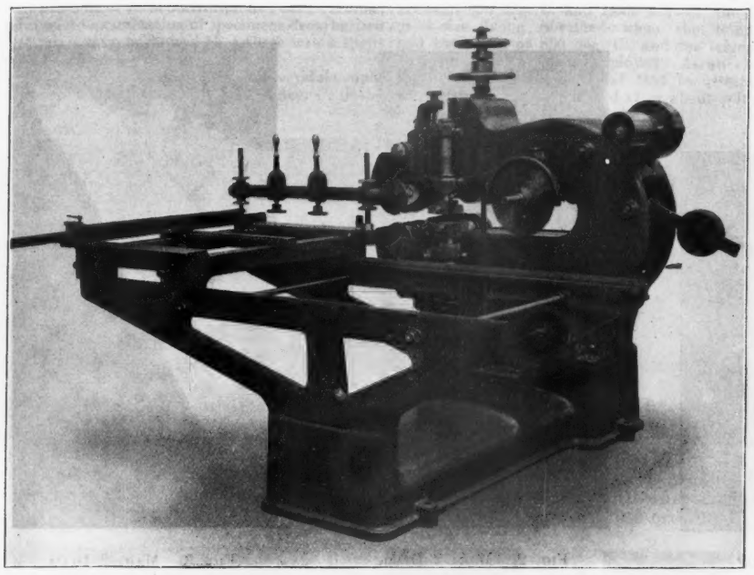


FIG. 1.

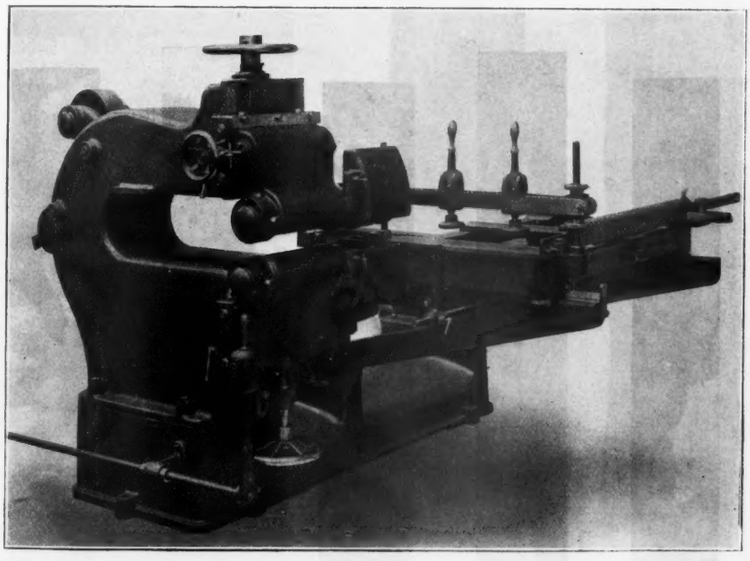


FIG. 2.

WADKIN TENONING MACHINE WITH INTERNAL DRIVE.

THE accompanying illustrations show two views of a design of tenoning machine recently introduced by Messrs. Wadkin and Co., of North Evington, Leicester. In addition to the usual tenoning operations, the machine is suitable for cross-cutting, trenching and other types of work. Timber up to 24 in. wide and 6 in. deep can be dealt with in it, and square or angular tenons can be cut, with equal or unequal shoulders, up to 6 in. lengths by a single movement of the table, while longer work is possible by moving the timber forward and continuing the cut, and, in addition, double tenons can be produced with equal facility. The standard machine has only one scribing spindle, the bottom one, but accommodation is provided for the other which may be fitted at any time. In addition a cutting saw, capable of working to a depth of 3 in., is also provided.

The main frame is a heavy casting, with a long gap, and is mounted on the base plate. Accurate machined surfaces give suitable bedding for the headstocks, each of which has a variable adjustment vertically, and motion may be given to either separately or the two may be moved together for the purpose of producing the tenon in proper central location. Setting is thus greatly facilitated. For unequal tenons a horizontal adjustment of the top headstock is available. When finally adjusted, movement out of position is made impossible by the use of a locking device. As the belt drive is carried within the main frame, ample protection is afforded, and the spindles being driven at the middle are effectively supported at each end in bearings, which have heavy ball races. This seems to be an improvement over the common arrangement of the overhung type. The cutter blocks give a shearing cut while spur cutters are fitted to give clean and accurately cut shoulders to the tenon. Ample guards surround the cutters, but as these are provided with hinges they may be readily swung aside to give access. The vertical scribing spindles are attached to the main headstocks and are therefore adjusted with them. In addition, however, they have independent adjustments. Ball bearings are fitted for their support, while their cutter blocks have four dovetail slots to carry the scribing cutters. The provision of a cutting-off saw makes possible the finishing of the tenoning to the desired length in a single operation, as it is carried on an adjustable sleeve which may be set to suit any required length of tenon.

Easy motion is given to the table by the provision of ball bearings for the roller spindles, which are protected against the intrusion of chips and sawdust, while the runways are kept clean by scrapers. Alignment of the table with the cutter blocks is at all times maintained. Two quick-acting lever cramps facilitate the setting of the timber and these are easily adjustable for various widths of work. The table fence has a turnover stop, which can be utilised with equal facility whether the fence is in a square or angular position. A special spring stop running right across the full width of the table is a part of the equipment and is put in place when it is desired to load the table with narrow stuff, such as sash bars, &c. The drive is arranged to give suitable speeds of cutting when the countershaft runs at 750 revolutions per minute, and this may either be got from shafting or directly from an electric motor of 6 to 8 h.p.

THE PRODUCTION OF LARGE CRYSTALS BY ANNEALING STRAINED IRON.*

By Professor C. A. EDWARDS, D.Sc., and L. B. PFEIL, B.Sc., A.R.S.M., University College, Swansea.

THE attention of the authors was directed to the commercial importance of coarse crystallisation in metals by a number of defective stampings which came into their possession, and the present research was carried out to determine more definitely the conditions under which very large crystals were formed in iron by annealing after plastic deformation.

The procedure adopted in the earlier of the experiments described was based upon the work on aluminium of Carpenter and Elam.

The metal employed was mild steel plate $\frac{1}{8}$ in. thick received in the condition in which it left the hot rolls. The analyses of three batches were as follows:—Carbon, 0·105, 0·130, 0·100; silicon, 0·021, 0·023, 0·00; manganese, 0·380, 0·440, 0·350; sulphur, 0·045, 0·028, 0·072; phosphorus, 0·019, 0·020, 0·086.

No difference was noticed in experiments made with batches No. 1 and No. 2. Batch No. 3, probably owing to the much higher sulphur and phosphorus content, gave less uniform results, and the authors do not consider it desirable to describe in any detail the experimental results obtained with this metal. The sheets were covered with a thin layer of scale, which was removed in all cases by pickling in dilute sulphuric acid, leaving a metallic surface dull but free from serious defects.

In the earlier experiments tensile test-pieces were cut from the sheet and machined to size, the total length being 6 in. and the parallel portion $2\frac{1}{2}$ in. by $\frac{3}{4}$ in. by $\frac{1}{8}$ in. But in later experiments strips were used 8 in. to 12 in. by 1 in. to 2 in. wide, these giving results which were fully as good as those from shaped test-pieces. Each specimen was, of course, stamped for the purpose of identification.

Chappell's work having shown that the presence of carbon in iron restricts the size of the crystals which could be developed, and the present authors' investigation of the defective stampings having shown that coarse crystallisation was more pronounced where decarburisation had occurred, it was decided to remove all carbon from these test-pieces before attempting to produce coarse crystallisation.

Decarburisation was carried out by heating in an atmosphere of hydrogen, and was considered to be complete when a polished and etched section appeared free from pearlite or cementite when examined under the microscope.

The specimens were strained on a 10-ton Buckton machine. Generally a 4-in. gauge length was used. Elongations were measured by means of dividers and a steel rule, the experimental error not exceeding 0·005 in., which on 4 in. is equivalent to 0·125 per cent.

The annealing of the strained specimens was carried out in the same furnace as was used for decarburisation.

In order to determine whether crystal growth had occurred during annealing the specimens were etched in dilute nitric acid (10 per cent.).

The first experiment was made with a series of ten test-pieces which, after being subjected to elongations ranging from 1 to 20 per cent. (in steps of 1 per cent. up to 5 per cent., and afterwards in steps of 3 per cent.), were annealed for 12 hours at 860 deg. C., and then allowed to cool in the furnace. On etching this series it appeared as if growth had not occurred in any specimen strained less than 5 per cent. The 5 per cent. specimen had crystals about $\frac{1}{4}$ in. in diameter throughout the parallel portion, and those which had

* Abstract of paper read at the meeting of the Iron and Steel Institute on May 8, 1924.

been elongated more than 5 per cent. had crystals which were progressively smaller as the elongation had been greater. On more prolonged etching, however, a coarsely crystalline structure appeared on the pieces which had been elongated 3 and 4 per cent. After this deep etching the surface of the metal was pitted, and this masked to a large extent the real macro-structure. It seemed evident that a thin film of metal retaining its original grain-size formed the surface of these two specimens, and this was clearly seen to be the case by an examination of the cross-section of a similarly treated specimen. In Fig. 1 cross-sections of four specimens showing the finely crystalline films are illustrated, the remainder of the field consisting in each case of a portion of a crystal. Six more test-pieces were prepared, and these received elongations of 2·5, 2·75, 3·0, 3·25, and 3·5 per cent. (plus or minus 0·125 per cent.) respectively, and were then annealed for 48 hours at 880 deg. C. Any considerable increase of annealing temperature in the case of iron was impossible because of the refinement occurring at A3, and owing to the presence of manganese Ac3 occurred in this material just below 900 deg. C. It was hoped that annealing for 48 hours instead of 12 hours would allow the absorption of this finely crystalline film, but on etching specimens so treated the film appeared to be of about the same thickness as before, nor could the absorption be made to take place by annealing similar specimens for 168 hours at 880 deg. C. It was decided, in future experiments, to take a thin cut from the surface of specimens which had only received a small elongation, so as to reveal the coarsely crystalline structure without deep etching.

As a result of further experiments it appeared that crystal growth could be induced by elongations of 2·75 per cent. or upwards, and that below 2·75 per cent. no readily apparent growth took place even in the inner portions of the metal, this being shown by the examination of numerous sections cut from such test-pieces. Figs. 4 to 11 show a series of these coarsely crystalline specimens, the largest crystal being about 3½ in. long by 1¼ in. wide, produced in a strip which had been elongated 2·75 per cent. The crystals were smaller the more the elongation had exceeded 2·75 per cent.

A large number of strips were then prepared, given elongations ranging from 2·5 to 3·5 per cent., and then annealed for 72 hours at 800 deg. C., the object being to see whether even larger crystals could be obtained.

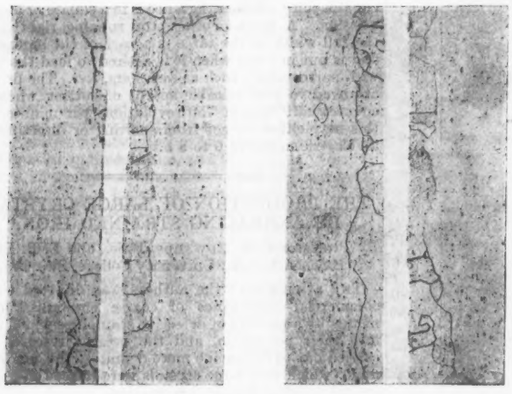


FIG. 1. MAG. 100 DIAM. CROSS-SECTION OF FOUR SPECIMENS SHOWING THE SURFACE FILM OF SMALL CRYSTALS.

FIG. 2. MAG. 2 DIAM. RECRYSTALLISATION ALONG BOUNDARY.

FIG. 3. MAG. 2 DIAM. SHOWING CRYSTAL GROWTH AT TOP OF WHITE CRYSTAL.

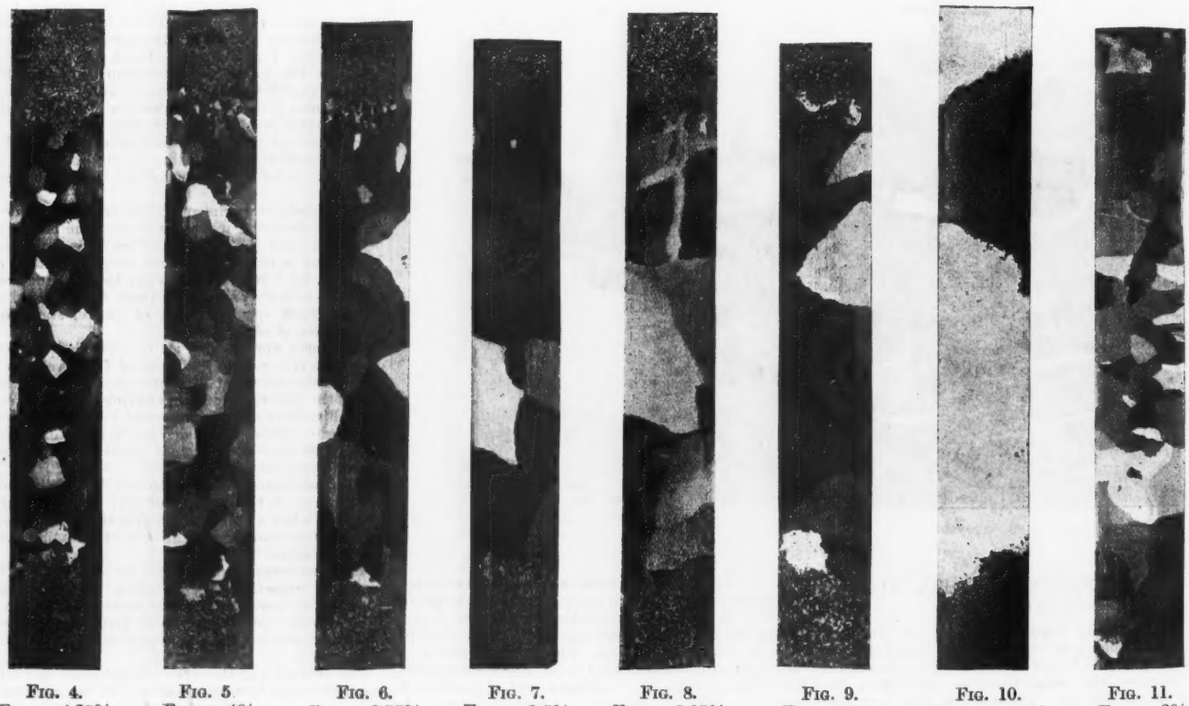


FIG. 4. ELONG. 4·25%

FIG. 5 ELONG. 4%

FIG. 6. ELONG. 3·75%

FIG. 7. ELONG. 3·5%

FIG. 8. ELONG. 3·25%

FIG. 9. ELONG. 3%

FIG. 10. ELONG. 2·75%

FIG. 11. ELONG. 2% BY ROLLING.

FIGS. 4 TO 11 DECARBURISED AT 925 DEG. C. FOR 48 HOURS. ANNEALED AT 880 DEG. C. FOR 72 HOURS. REDUCED TO HALF SIZE.

For some considerable time the authors entirely failed to get crystal growth. The only differences that could be found between these tests and the earlier and more successful ones were that, in the present instance, decarburisation had been carried out at a somewhat higher temperature—975 deg. C. instead of 925 deg. C.—and that the time of decarburisation had been variable. A careful micro-examination of specimens decarburised at these temperatures showed that there was a slight difference in grain-size.

Further tests showed that very large crystals could be obtained in metal decarburised 975 deg. C. if the size could be varied, the authors made use of the three following:—(1) Variation of the decarburisation temperature. (2) Variation of the length of time at the decarburising temperature. (3) By straining followed by annealing.

Specimens were decarburised at temperature between 850 deg. C. and 1,050 deg. C., the smallest grain-size being obtained when the temperature had been held at 850 deg. C., and the largest when 1,050 deg. C. had been employed. As an exception to the above it was noticed that in certain strips which had been decarburised at or about 900 deg. C. direction of rolling can be detected. Fig. 13 represents the metal after it has been completely decarburised in 48 hours at 850 deg. C. The number of grains per square millimetre is approximately 1,750. Similar material is referred to, in what follows, as grain-size A. Fig. 14 shows the grain-size obtained by decarburising at 950 deg. C. for 48 hours, and contains approximately 120 grains per square millimetre—grain-size B. Fig. 15, obtained from material which had been decarburised at 950 deg. C. for seven days, contains 80 grains per square millimetre—grain-size C. Fig. 16 decarburised at 1,050 deg. C. for seven days, contains

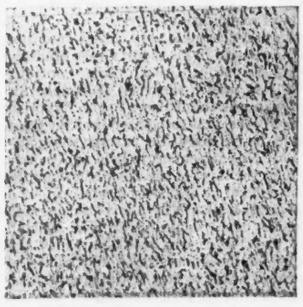


FIG. 12. MAG. 100 DIA. UNTREATED STEEL.

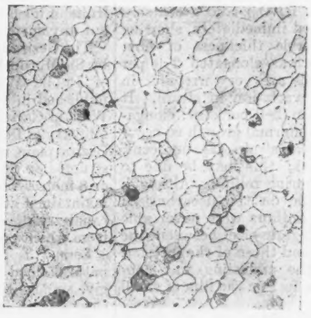


FIG. 13. MAG. 100 DIA. GRAIN SIZE A. DECARBURISED FOR 48 HOURS AT 850 DEG. C.

FIG. 14. MAG. 100 DIA. GRAIN SIZE B. DECARBURISED FOR 48 HOURS AT 950 DEG. C.

FIG. 15. MAG. 100 DIA. GRAIN SIZE C. DECARBURISED FOR SEVEN DAYS AT 950 DEG. C.

FIG. 16. MAG. 100 DIA. GRAIN SIZE D. DECARBURISED FOR SEVEN DAYS AT 1,050 DEG. C.

FIG. 17. MAG. 100 DIA. GRAIN SIZE E. DECARBURISED FOR 21 DAYS AT 1,050 DEG. C.

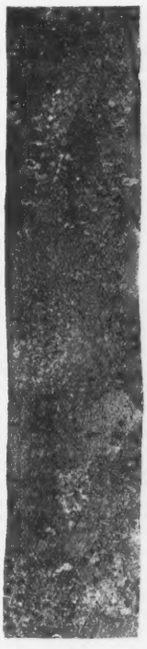


FIG. 18. NATURAL SIZE. ELONG. 50% BY ROLLING. RECRYSTALLISED IN PARTS.

FIG. 19. NATURAL SIZE. ELONG. 75% BY ROLLING. ALMOST COMPLETE RECRYSTALLISATION.

NOTE.—FIGS. 18 AND 19 HAVE BEEN REDUCED BY ONE-QUARTER.

elongation exceeded 4 per cent., but the largest crystals were not so large as those which had been obtained in strips decarburised at 925 deg. C. and elongated 2·75 per cent.

The grain-size of a decarburised specimen always appeared to be uniform, and fairly stable conditions should be obtained after periods of time judged so as to allow 12 hours at the decarburising temperature after all carbon had been removed. That the initial grain-size of a metal affects grain-growth has been suggested by several workers.

Influence of Initial Grain-size.—Experiments were carried out to obtain further information on the relation between grain-size before straining and the minimum strain required for abnormal crystal growth. Of the many ways by means of which the initial grain coarse columnar crystals were obtained similar to those observed by Stead, Austin and others.

Further differences in grain-size were obtained by making the decarburising period vary between two and seven days. A much faster stream of hydrogen was required to complete the decarburisation in the shorter times. Factors, such as the rate of cooling after the completion of decarburisation, were kept constant, so that, whenever desired, more specimens of any particular grain-size could be obtained. By these means the authors obtained a sufficiently wide range of crystal sizes for the experiments about to be described.

The structure of the original untreated steel is illustrated in Fig. 12, which shows fine grains of ferrite along with a considerable amount of pearlite. The

50 grains per square millimetre—grain-size D. Fig. 17 does not give a true idea of the actual grain-size. This material was decarburised for 21 days at 1,050 deg. C. and was of very much coarser grain than D (Fig. 16), containing only about 16 grains per square millimetre—grain-size E. Test-pieces of each grain-size were strained to various degrees and then annealed at 880 deg. C. for 72 hours. They were then examined to determine the extent to which grain-growth had occurred.

The more important results may be summarised as follows:—*Grain-size A.:* Minimum elongation for abnormal growth, 2 per cent. The largest crystals produced were not so large as those with grain-size B. *Grain-size B:* Minimum elongation for abnormal growth, 3·25 per cent. Larger crystals were produced in this material than in any other, the maximum size being 4 in. by 1¼ in. by ⅛ in. *Grain-size C.:* Minimum elongation for abnormal growth, 3·75 per cent. The largest crystals were larger than those obtained with grain-size A, but smaller than those for series B. *Grain-size D.:* Minimum elongation for abnormal growth, 4·25 per cent. In this series none of the crystals was over 1 in. long, and all were covered by a "thick" film of small crystals. *Grain-size E.:* Crystal growth was very limited and difficult to detect. The elongation required seemed to be about 8 to 12 per cent.

In specimens with a grain-size larger than E, and tests were made on specimens of gradually increasing grain-size up to 1 in. diameter crystals, recrystallisation usually occurred on annealing before grain-growth was detected. In general, the greater the grain-size the greater the strain necessary to cause either growth or recrystallisation. With coarsely crystalline specimens the strain was never uniform, and varied very much from crystal to crystal. For example, a specimen with 1-in. crystals, which had been elongated 20 per cent. over a length of 4 in., contained individual crystals which were elongated 15 per cent., whilst others were elongated as much as 26 per cent. On annealing this specimen at 880 deg. C. for 24 hours, recrystallation had only occurred to a limited extent round certain grain boundaries, the previous crystallisation in other parts remaining unaltered. Fig. 2 shows a boundary (at a magnification of 2 diameters) where recrystallisation had occurred. Fig. 3 illustrates a case where grain-growth was detected in 1 in. diameter crystals. The old boundary, which was almost a straight line, was common to two crystals, one of which had been elongated 19 per cent., and the other 20 per cent. Annealing at 880 deg. C. was continued for 48 hours. At the end of this time it was seen that one crystal has pushed forward the boundary in several places (see upper part of light crystal in Fig. 3, the dark round markings on this crystal are due to Brinell impressions).

It was usually found to be impossible to strain large crystals sufficiently in the tensile machine to induce either growth or recrystallisation. Fracture occurred after about 40 per cent. elongation and on annealing recrystallisation only occurred at points very near the fracture. Some coarsely crystalline strips (1 in. diameter crystals) were therefore rolled to produce

elongations from 20 per cent. upwards. These were then annealed at various temperatures for various length of time. It was only very rarely that growth could be detected. Generally the first sign of change consisted of recrystallisation at the grain boundaries after an elongation of about 25 per cent., and was followed by a slow growth of the new crystals. After 50 per cent. elongation, recrystallisation occurred throughout some crystals, producing new crystals about 1 to 2 millimetres in diameter; in other crystals, however, no change occurred, except at the boundaries. Prolonged annealing here again caused little change. After 75 per cent. elongation only a few of the crystals were able to resist recrystallisation during the annealing, and with somewhat greater elongations recrystallisation occurred throughout the specimens (see Figs. 18 and 19).

It has been suggested, particularly by Jeffries, that strain gradients and temperature gradients would favour the production of coarse-grained structures. In order to determine whether, by introducing these two factors, still larger crystals could be produced in the decarburised steel with which the author were working, a number of tapered strips were cut. The taper varied from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. per foot, specimens being 8 in. long by $1\frac{1}{4}$ in. wide in the centre. These were strained so as to give an elongation of about 3 per cent. in the centre, the elongation being measured for each 1 in. of length. Test-pieces of this kind, with a strain gradient, were then annealed along with a number of uniformly strained pieces for comparison, but after the examination of a considerable number of specimens it was not possible to state that there was generally an appreciable difference between the largest crystal produced in the two cases. If a specimen uniformly elongated 3·5 per cent. developed crystals about $1\frac{3}{4}$ in. long, then in a tapered test-piece the portion which had been elongated about 3·5 per cent. also had crystals $1\frac{3}{4}$ in. long. If, in one case, abnormal grain-growth did not occur below 3·25 per cent. elongation, then the same held good in the other case.

Further experiments were made to see if a temperature gradient caused any appreciable change in the large crystals produced. Specimens uniformly elongated to various degrees were placed in the furnace, so that one end of each would be at 880 deg. C. and the other at a much lower temperature. On examination here again negative results were obtained, that portion of each test-piece which now had large crystals had not larger crystals than an equally elongated specimen which had been annealed under conditions where the temperature gradient did not exceed 3 deg. C. over the whole length.

In their work on aluminium Carpenter and Elam found that to produce very large crystals it was an advantage to heat up their strained specimens slowly, since the lowest possible temperature at which growth took place at all was the most suitable for growing the largest crystals. No difference in the final crystal size, however, could be detected in any of the authors' experiments, whether the temperature was raised from 600 deg. C. to 880 deg. C. fairly uniformly over three days, or whether 880 deg. C. was reached within an hour of placing the specimens in the furnace. The authors suggest that this difference in the behaviour of the two metals may be due to a much more rapid increase in the mobility of aluminium atoms between 450 deg. C. and 550 deg. C. than would occur with iron atoms between 800 deg. C. and 900 deg. C., for example. Carpenter and Elam's aluminium specimens were annealed over a range approximating to 15/18 to 17/18 of the absolute melting point, whereas in the case of iron the example given above would be approximately from 11/18 to 12/18 of the absolute melting point.

Experiments relating to the Surface Film. — A number of specimens were pickled free from surface scale and then passed between polished hard steel rolls, this giving the metal a mirror-like surface. These specimens were then decarburised in the usual manner. Specimens prepared in this way were then strained to various degrees. Annealing was then carried out for various lengths of time. On examination the film was seen to be as thick as ever, and the authors concluded that the surface film was not connected with the surface smoothness of specimens. Some strips were cut from the $\frac{1}{4}$-in. sheet, and the surface ground down so as to remove a thickness of metal somewhat greater than the usual thickness of the film (0·005 in.). These strips were then decarburised, strained, and annealed, but on examination no diminution of the film thickness could be observed. From the examination of many cross-sections, it was noticed that in general the film was just one crystal thick (Fig. 1). That the thickness of the film varied with the original grain-size had been noticed throughout these experiments, the film being thicker when the grain-size was larger. It seemed reasonable to assume therefore, that those crystals in the original material which had a "free boundary" did not undergo the same kind of change during deformation as the interior crystals.

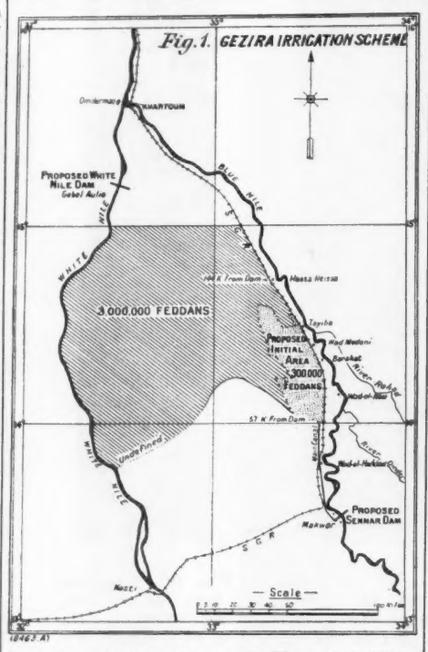
If straining were carried out by rolling, the surface crystals would be compressed between the rolls. No longer having "surface freedom," they might be forced to undergo the same kind of change as the interior crystals, in which case the fine surface crystals should disappear during annealing. Accordingly, after marking a 6-in. gauge length on some decarburised strips, linear elongations from 2·0 per cent. to 4·0 per cent. were produced by rolling. These strips were then annealed for 72 hours at 880 deg. C. The strips were then immersed in etching solution (10 per cent. HNO_3), and a coarsely crystal line structure developed immediately, showing the absence of any appreciable thickness of film. Fig. 11 shows a strip which was elongated 2·0 per cent. by rolling. The crystals are very irregular in size, no doubt due to small variation in strain. It should be noted that the strain (2·0 per cent. elongation) which has allowed this abnormal growth to occur is less than the tensile critical strain ($2\frac{1}{2}$ per cent. elongation) of similar material; this may be due to the lateral spread occurring during rolling. Although many observations were made on the decarburised but unstrained material, the authors were never able to detect any difference in grain-size between the crystals of the surface layers and those of the interior. The atmosphere in which the annealing was conducted was found to have no effect on the film of small crystals.

(To be continued.)

IRRIGATION PUMPING MACHINERY (GEZIRA SCHEME), SUDAN.*

By RICHARD W. ALLEN, C.B.E., Vice-President.

THE object of the Gezira (or island) irrigation scheme is to provide, for the purpose of growing cotton, the irrigation of the northern portion of the Gezira plain, which may be roughly described as the triangular tract of country lying between the Blue and the White Niles in the Sudan, south of Khartoum (see map, Fig. 1).



The principal cotton-producing country in the world is the United States of America. Careful investigations into the world's requirements point to the fact that there is a world shortage. It was this fact that rendered it necessary for the position to be carefully reviewed, and for efforts to be made to ascertain what promise there is for procuring suitable and increased supplies within the Empire and from other parts of the world under British influence. In the Sudan the prospects are bright. The large and immediate increase of the cotton-growing area is now assured, and during the next few years it will be possible to bring under cultivation an area of nearly half a million acres in the Blue Nile and Kassala areas.

The system under which the bulk of the cotton is at present being grown in the Sudan is extremely interesting. The proceeds of the crop are pooled, and the results are distributed on a carefully thought-out plan. The Government supplies the land and the water, the native does the cultivation, and the Sudan Plantations Syndicate undertakes the general management, the minor canalisation, ploughs the land and supervises the cultivation, does the ginning and finances the crop. The system was warmly approved by the late Lord Kitchener and commanded the complete confidence of the native. This scheme is worthy of careful observation, as it would seem, at all events in the areas above described, to secure to the native the full fruits of his labour, and to retain him on the land without any suspicion of exploitation.

The Gezira Irrigation Scheme is very clearly described by Sir Murdoch Macdonald in his report to the Ministry of Public Works, Egypt, entitled "Nile Control," published in 1920. It was in the year 1899 that Sir William Garstin, who was the Adviser to the Egyptian Ministry of Public Works, first recognised that the great Gezira plain might be irrigated if a barrage were constructed on the Blue Nile at Sennar, to hold up 7 metres or 8 metres whereby the level of the Blue Nile could be maintained at flood level at any season, and so feed a canal taking out of the Blue Nile above the barrage from which point the canal would run to Wad Medani.

Sennar is the most northerly point at which the natural flood level of the Blue Nile would suffice to give sufficient head of water to flow in the canals of the Gezira plain from Sennar to Wad Medani.

The total area of the Gezira—the plain lying between the White Nile and the Blue Nile, immediately south of Khartoum—has been calculated at approximately 10,000,000 feddans (roughly as many acres). Of this area it is estimated, from the general soil conditions and the results obtained during the last eleven years on the cotton growing stations at Tayiba, Barakat, and Hag Abdalla, that a large proportion of the area lying between the 14th and 15th parallels of latitude and comprising some 3,000,000 feddans is capable of growing cotton of high quality and of satisfactory yield. The area upon which a commencement is being made comprises 300,000 feddans (see map, Fig. 1).

It must be recognised, in preparing a scheme of such magnitude, that much time is taken in discussion and experiments before any general approval can be obtained. For the purpose of testing the suitability of the Gezira soil, an experimental pumping station was erected in the year 1911 at Tayiba, which is situated about 11 kilometres north of Wad Medani. The results of this station were most successful, and it was decided that further pumping stations should be installed and not to wait until the completion of the dam for the development of the scheme.

A second pumping station was erected in 1914 at Barakat, a short distance south of Wad Medani. The third pumping station was erected in 1921 at Hag Abdalla, south of Barakat. The fourth, and largest of all, the subject of this paper, was completed in June, 1923, at Wad-el-Nau, which is situated between Hag Abdalla and Barakat.

Irrigation by means of these four pumping stations is generally carried on during nine months of the year, from about July 15 to April 15, and owing to the high atmospheric temperature of the day, all pumping is done at night between the hours of 9 p.m. and 9 a.m. The whole Gezira irrigation scheme as outlined by Sir Murdoch Macdonald is now being completed, and is a stupendous engineering undertaking.

The dam is actually at Makwar, a few miles south of Sennar, and is in course of construction, two miles in length, and when this is completed, as it is contemplated, in 1925, it will be one of the greatest engineering constructions of its kind in the world. The main irrigation canal leading from the Makwar Dam to that part of the plain to be irrigated, and the smaller irrigating canals, are nearly completed. A portion of the canal system is now in use conveying water from the four pumping stations.

WAD-EL-NAU PUMPING STATION.

In the early part of the year 1922 a start was made on the erection of the fourth pumping station at Wad-el-Nau, which station is situated about 180 ft. from the river bank on the west side of the Blue Nile. It was determined that the quantity of water required from this station should be approximately 52,000 gallons per minute.

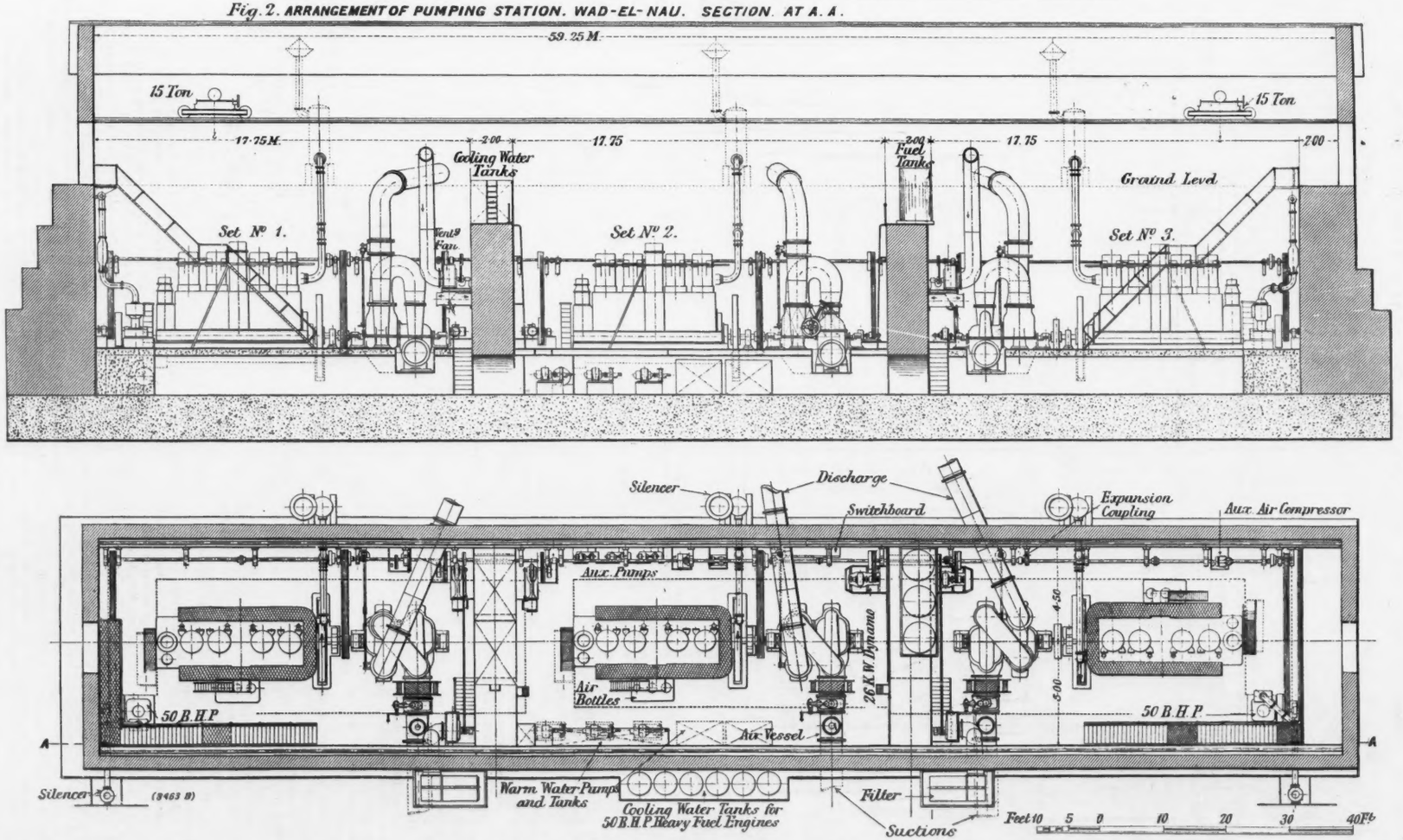
Owing to the distance of Wad-el-Nau from the main irrigation canal, which flows from the dam at Makwar to Wad Medani, it was necessary to construct a feeder canal, and it was decided that the water should be pumped from the station to the feeder canal through a rising main nearly $\frac{1}{2}$ mile long. This determined the head, namely, 83·6 ft., against which the pumps had to work. It was further decided that, owing to the difficulty of obtaining coal or wood for fuel, Diesel oil-engines should be installed for driving the pumps.

* Paper read before the Institution of Mechanical Engineers on Friday, May 9, 1924. Abridged.

THE WAD-EL-NAU PUMPING STATION FOR IRRIGATION IN THE SUDAN.

CONSTRUCTED BY MESSRS. W. H. ALLEN, SONS AND COMPANY, LIMITED, ENGINEERS, BEDFORD.

Fig. 2. ARRANGEMENT OF PUMPING STATION. WAD-EL-NAU. SECTION AT A.A.



and that they should be three in number, each pump to be capable of delivering 26,000 gallons of water per minute, two working together and one set as spare.

Choice of Site.—Great care must be exercised in choosing a site for a pumping station on the Nile, which, by reason of its constantly changing course, is liable, where an unsuitable site has been selected, to leave the suction wells high and dry. As an illustration of this, on the opposite shore to that on which the Wad-el-Nau station stands, is a very large sandbank, extending in width at least 200 yards from the original bank of the river.

Construction of Engine House and Pump Wells.—Excavation for the building of the station, which is 194 ft. long and 31 ft. wide, and the suction wells in the river, was started in February, 1922. In both cases it was a race against time, as the wells had to be completed before the rise started in June; while the building had to be finished, and the excavations filled in to protect the building, before flood time in July and August. The maximum depth was 46 ft. over a length of about 260 ft. and a width of some 68 ft., but the width at the top had to be increased to about 176 ft., to allow for the natural slope of the sides of the excavation, with the result that in all approximately 65,000 tons of soil had to be removed. The whole of the work was manual, the material being removed in wickerwork baskets, each holding about 1 cwt. of soil, and of which three would be carried out at a time by one man. The main foundations consisted of a bed of concrete, 8 ft. 3 in. deep, under the whole building, with an additional 8 ft. 3 in. on top of this under the main engines, while the walls were 14 ft. thick at the bottom, but stepped to 3 ft. 3 in. at the top.

It is of interest to note that all the bricks were made in kilns, within a few yards of the site, by native labour, and although a little irregular in shape, were of excellent quality and well suited to the purpose. The building was ready for the installation of the plant in October, and, to avoid too great a pressure on the new walls, the water was allowed to rise in the building until the drop of the Nile in September.

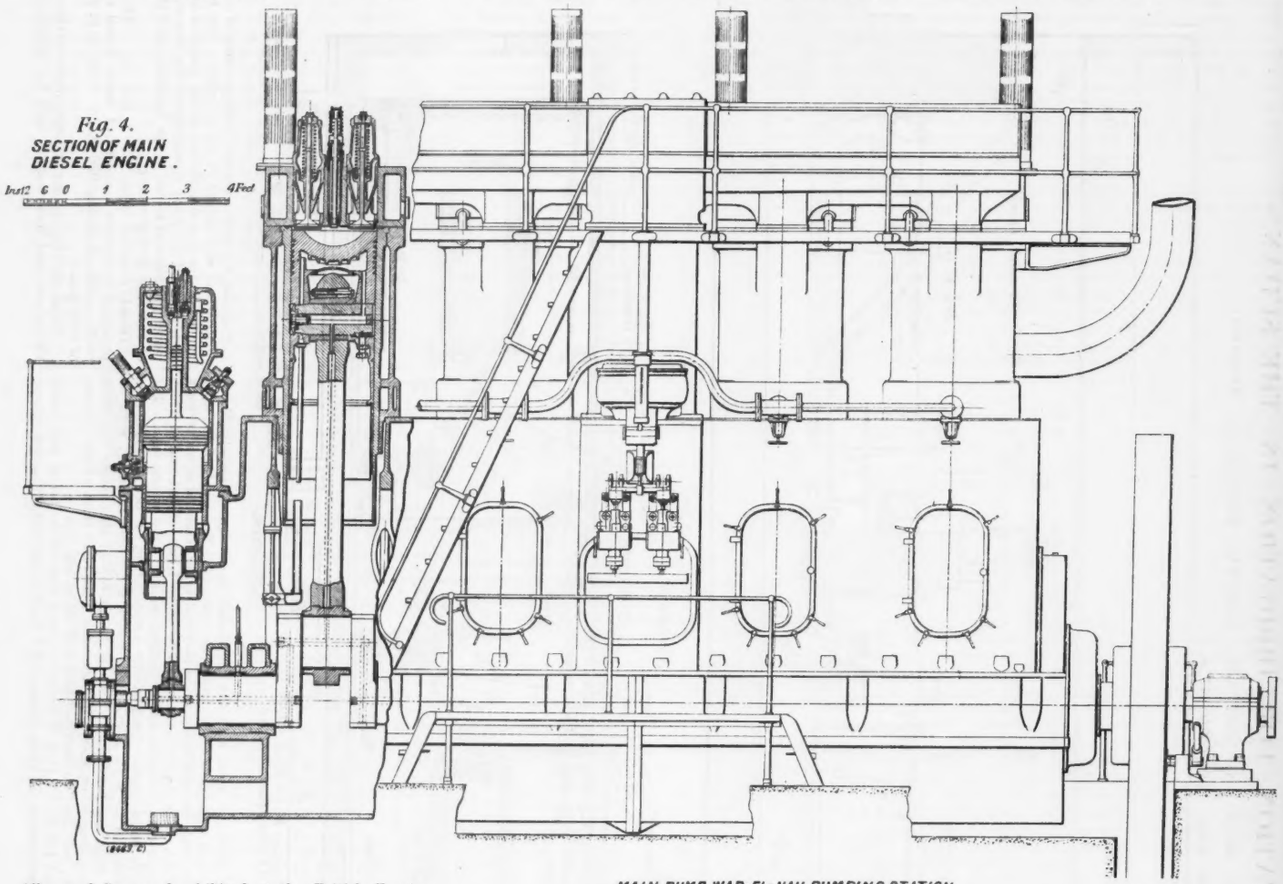
Diesel Engines (Figs. 2, 3 and 4).—The main pumping machinery consists of three Diesel engines, each capable of giving 950 b.h.p. running at a speed of 150 r.p.m.

[These are very similar in construction to the smaller Burmeister and Wain engine built by Messrs. W. H.

MACHINERY FOR THE WAD-EL-NAU PUMPING STATION; SUDAN.

CONSTRUCTED BY MESSRS. W. H. ALLEN, SONS AND COMPANY, LIMITED, ENGINEERS, BEDFORD.

Fig. 4.
SECTION OF MAIN DIESEL ENGINE.



Allen and Sons and exhibited at the British Empire Exhibition.*—ED. E.]

Main Pumps (Figs. 5 and 6).—The main centrifugal pumps are three in number, and are of special design. Each pump has two casings, bolted together, being joined in series by means of a steel connecting pipe, while the two similar impellers are carried on one shaft. The duty of each pump is to deliver 2 cub. metres per second (or 26,000 gallons per minute) against a maximum total head of 83·6 ft., this head being based on the assumption that the water-level in the river does not fall below 1,279 ft. above sea-level (at Alexandria) and that in the delivery canal does not rise to more than 1,349 ft. above the same. Two of the main centrifugal pumps are normally delivering together into the canal, the third set being a standby.

Auxiliary Machinery.—The auxiliary machinery of the station consists of two 50-h.p. hot-bulb engines, driving, by means of friction clutches, 187 ft. of shafting fitted with ball bearings and expansion couplings. These 50-h.p. engines are only used for starting purposes, after which the shafting is driven by the main engines. They are again used on shutting down, to maintain the circulation of the cooling-water for the Diesel engines for a time. The shafting is used for driving the vacuum-pumps, make-up pumps, the dynamos and an air-compressor for the initial charging of the air-bottles. This auxiliary compressor has an approximate capacity of 11 cub. ft. of free air per minute at a pressure of 1,000 lb. per square in. Other auxiliaries, which are motor driven, include three cold and three warm-water pumps for circulating.

Cooling Water System.—For the removal of silt from the cooling water a concrete settling tank was built near the junction of the three 40-in. discharge-pipes, and was fed by a 6-in. branch from the same. After passing through the tank, alternately over and under a series of partitions, the water gravitates to steel tanks in the pumping-station, which in turn supply the cooling-water pumps. The visible outlets consist of funnels mounted on the top platforms of the main Diesel engines, and after passing through these the water gravitates to tanks in the basement,

* See page 530 *ante*.

MAIN PUMP, WAD-EL-NAU PUMPING STATION.

Fig. 5.

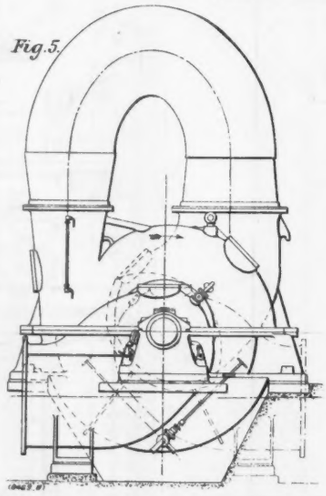
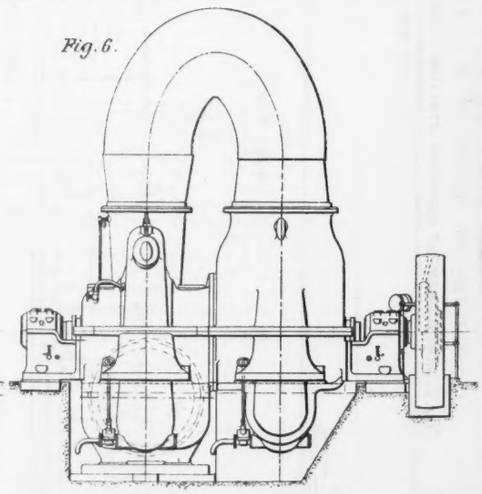


Fig. 6.



which, to ensure that the pumps always remain fully charged, are maintained at constant level by means of a reflux-valve fitted on the outlet side. These tanks are discharged by the warm-water pumps to the river, and to prevent them overflowing and flooding the basement a float-chamber with electric alarm-gear is installed, whereby a bell is rung as soon as the water level reaches to within 3 in. of the top.

Charging Arrangements for Main Pumps.—The horizontal vacuum-pumps used for charging the main 45-in. pumps are driven by belts from shafting, and exhaust at the rate of 2,100 cub. ft. in 10 mins. They are connected by a 3-in. pipe with branches, to three air-vessels and pumps. To prevent water being drawn into the vacuum-pumps and causing damage, a charging-tank fitted with a ball-valve was installed; while, to help to check any sudden rush of water, perforated diaphragms were also inserted in each of the three branches leading to this tank. Should water enter this, the ball-valve closes and the water is prevented from getting beyond this tank. In this case the system has to be drained.

As an additional safeguard against the ball-valve not working a barometric-pipe, rising to a height of nearly 40 ft. above supposed high water-level, was fitted above the charging tank. As the Nile rises some 40 ft. during the wet season, the varying conditions under which the vacuum-pumps have to operate can readily be appreciated.

(To be continued.)